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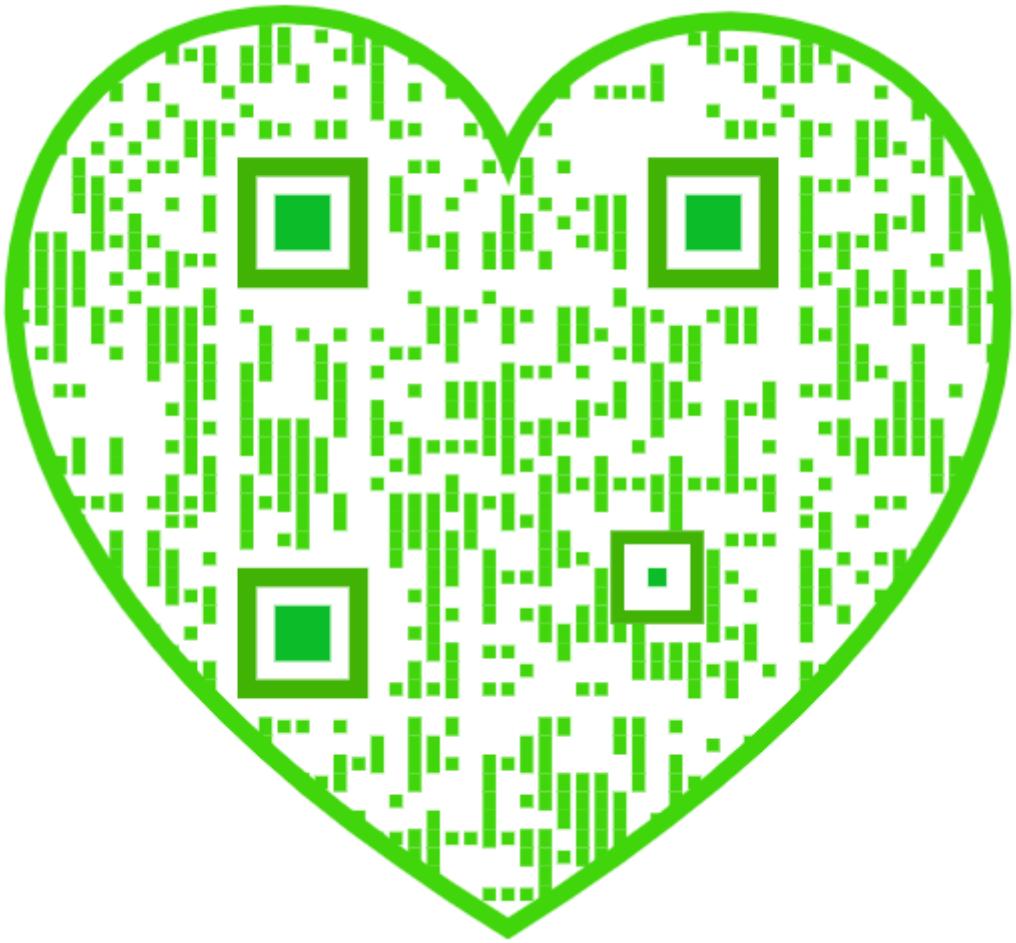
CORN CULTURE

New Methods
Versus Old

Price One Dollar

By WILLIAM G. DEARING
LOUISVILLE, KENTUCKY



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LOUISVILLE, KENTUCKY

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JOHN P. MORTON & COMPANY

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1913

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CORN CULTURE

CHAPTER I

THE FARM

About the middle of September, 1912, I was sitting on the veranda in the front of my house, looking at the beautiful landscape along the Ohio River, between the hills on the Kentucky side and the hills on the Indiana side. The house is on a small ridge in the center of four hundred acres of land, some ten miles from Louisville, Kentucky. In the distance could be seen the smoke hanging over the populous and energetic city, and the gentle Ohio, winding its course at the foot of the Indiana hills. The reddened leaves on the trees and the changing color of the corn, indicating that the year's work was nearly done, and the singing and twittering of the birds on a nearby beech, which broke the silence and serenity of the bright morning, all made the scene one not easily forgotten.

On the south side of the farm the L., H. & St. L. Railway runs, and the St. Louis Limited, with its excellent train of Pullmans, had just passed; on the north side of the farm is the Illinois Central Railroad, and the Panama Express with its fine vestibuled train was just passing. A little distance beyond is the old Louisville & Nashville Turnpike, along which the traffic from the Ohio River Crossings passed South before the days of railway transportation, and where now runs the interurban electric road, extending from Louisville to Orell. An interurban car could be seen for a distance of two and a half miles, and just as I was looking over the valley north, I saw the electric car coming down its road from Louisville and stop at Finley Station.

A gentleman got off, and after talking with another gentleman standing near, he started in the direction of my home. He was soon near the house, and I saw it was my old friend Doc Saunders, who was a client of mine when I lived in the good old town of Flemingsburg. Doc com-

menced life a poor man, and being the possessor of a fine mind he soon was a successful trader, and is to-day a very wealthy man. It has been my pleasure to know a number of men, and to count them as my friends, and it has always been a great privilege to have known Mr. Saunders. As he approached, I left the veranda to meet him. "How do you do, Doc? How are you, any way? This is indeed a great pleasure, and I am so glad to see you."

Saunders. I am very well, Drenan, and I am as equally glad to see you. You are looking well, and I am so glad, Will, to see you enjoying such good health.

Drenan. Let us go to the house, where we can sit down and rest a little, and I know you will enjoy a good cold drink of water. I will call the hired boy, who can go down and pump some water. You know we have a natural gas well here, which furnishes the power to pump the water for the stock, the house, and the farm.

Saunders. This is, indeed, a great convenience, and should add greatly to the value of your farm. I wish I had one on my farm in Fleming County.

Drenan. I told the boy to pump a lot of water out, so you would have it pure and cold, and here he comes. You see this water percolates through the sand, and the bottom of the well is below the water in the Ohio River, and I believe it is as pure as we can find.

Saunders. It is indeed fine, and cold. What a great beverage! Water is the only drink fit for the human race. I cannot understand why any man would want beer, ale, or whiskey, when he can get such water as this. Alcohol deadens the nerves, impairs the efficiency of the different organs, and is a curse to all who use it.

Drenan. I see you are the same old Doc. You were always a prohibitionist. As you have always had such a clear head, been so healthful and made such a success of life, I am not going to discuss prohibition with you. I expect I am as much of a crank on the subject as you are, and I don't believe there would be much chance to get up a discussion on the subject. Of late years, Doc, I have become very much interested in scientific agriculture, and I want you to tell me of your successes on the farm, that I may profit by them.

Saunders. I have heard of your success as a corn raiser and a renewer of soil fertility, and while I was in Louisville I thought I would come down to your farm and see your corn in the field and talk over old times with you, and learn what I could.

Drenan. You pay me a high compliment, indeed, and I assure you I appreciate it very much, but I expect you will teach me more than I can tell you; nevertheless, we will talk over corn culture and many other things while you are here, and maybe we can be of mutual advantage.

Saunders. Is this the field back of the house where it is said you have such a fine crop of corn? It certainly looks all right. Let us go out and look at it.

CHAPTER II

THE CORN FIELD

Drenan. Yes, It contains eight acres, and I consider it a very fine piece of corn. We will take a walk through it, so you can see it on close inspection. Here is your hat, and we will go through the yard and out the gate nearest to it. You see the land is a sandy loam, and easily cultivated.

Saunders. Look here, Drenan, here is a stalk of corn with four big ears on it. This is out of the ordinary. Here is another with three. Why, look at the great number with two large ears on the stalk! I am surprised. When your foreman came to Fleming, and told of the great corn crop on your eight-acre field, I thought he was exaggerating some. Seeing, however, is believing. It is indeed wonderful. I don't understand how you could raise such a crop on this land. I saw it a year ago and I was not much impressed with it. The crop is extraordinary.

Drenan. I am glad you think it so good. I want to show you something you never saw before. I have a wonder for you to see. It is a stalk of corn with eight ears on it, five are large ears and three are small. It is phenomenal. It is on the north side of the field. I want you to see it. As we go, you can see what a fine crop of cow-peas I have in the corn.

Saunders. These are fine cow-peas, and before I go home I want you to explain why you put cow-peas in your corn. Indeed, I want you to explain in detail how you raised this big crop of corn.

Drenan. Here is the stalk with eight ears on it. You see the three largest ears are highest up. The fourth and fifth are not as large as the sixth, seventh, and eighth. The

eighth ear is of good size. Nature has some way crossed herself. The stalk is a freak. I don't exactly understand it.

Saunders. Who would have thought it? Look! the lowest ear is nearly as big as the top one. You have fine big ears on the stalk, and each is as large as the ordinary ear on corn. If a man had an acre like that he would raise at least three hundred bushels on it. My recollection of this field is that it was wet and cold, and I thought the probabilities of raising anything on it were remote.

CHAPTER III

DRAINAGE

Drenan. This field was wet and cold when you saw it. I had just bought the place and had commenced to improve it. The first thing I did was to make two big ditches through the field so as to take off the water. The greater part of the field was wet and soggy. The ditches had stopped up, and the water could not go off. After making the two ditches, I made small transverse ditches so the water could lead off at once. You would be surprised at the transformation of soil in one year. I consider good drainage one of the most important things in raising a bounteous crop. If water stands in the land for any length of time, the land is virtually ruined so far as the raising of a crop is concerned.

Saunders. Why is this, as water is necessary in the raising of any crop? It looks as if the more water we have, the better crop we should raise, although I know cold, wet land will not produce anything.

Drenan. You know that chemistry has enabled us to learn many things we did not know. Oxygen in the air is necessary for animal life, and it is also necessary for plant life. Oxidation is always going on in the interior during plant life, and the plant is continually consuming a small quantity of oxygen and throwing off a small quantity of carbonic acid gas. When plants have green leaves, they absorb carbonic acid gas and evolve oxygen. It is as much necessary for the plant to have oxygen as the human being. Put a human being below the water and he drowns; likewise put an ordinary plant below the water and it dies. When you shut off free oxygen from reaching the plant roots, you strangle the plant and it dies. When water

stands on soil and it becomes cold and wet, deoxidation is active, the nitrates present are destroyed, and most of the nitrogen passes off in gas. The soil will consequently suffer a considerable loss of plant food by lack of drainage. There can be no soil ventilation in cold, wet land, and before any crop can be grown on it, it must be well drained.

You can not revive a piece of worn-out land until it is thoroughly drained, either by surface ditches or tiles. The more ditches you have the better, it does not matter whether the water stands on it or not. There can be no danger in having too many. If they are surface ditches, they should be deep enough to have thorough drainage at once. This enables one to plow deep, to pulverize the soil, to conserve the soil moisture, to promote soil ventilation, to encourage the deep rooting of all plants, and to give the proper temperature to soil. Compact and cold soils are not conducive to plant growth. The plant roots cannot find room enough in which to grow.

Saunders. Why, Drenan, you really surprise me with your full knowledge of agriculture. You talk like an old farmer. You are a lawyer, and I would like to know how and why you have become so interested.

Drenan. Yes, it is true that I am a lawyer, and I make my living by practicing law. I once had a case for a railroad involving the rates on phosphate rock from the Mt. Pleasant mines in Tennessee to the Ohio and Mississippi River Crossings. These rocks are taken from the mines to the different factories and are treated with acid and other ways and are then sold to the farmer as fertilizers. In the study of the case, I learned that these rocks had to be treated with sulphuric acid before the alum and the iron in these rocks became soluble so that plant life could reach the phosphate and potash in them. Alum and iron are very insoluble, and they are very hard to release from the rock. The rock is sold according to the percentage of alum and iron in them. If they have a large amount, the rock is almost worthless. The smaller the amount of these, the better price the rock brings.

I became very much interested, and this gave me a desire to make more investigations, and I have been keeping it up. I took a course of study in chemistry under Pro-

fessor Parks in the Manual Training School in Louisville. I made quite a number of experiments under him, and I have been able to experiment with the different elements and to know the effect of combinations. It was an interesting study, and has been of great service to me. When I use the word "oxidizing" or "deoxidizing," I know just what is meant. I do not see why all the common schools in the country do not have chemistry in all the grades, so that the knowledge of the subject would be thorough, full, and complete.

Upon learning that sulphuric acid was used to release the alum and the iron in phosphate rock, I conceived the idea that there was some way that this acid could be made and used by plowing under a green crop of plant life. We will talk of this a little later, as I have some things to show you that will convince you that I know what I am talking about. I am so fully impressed with the importance of thorough drainage that I am going to tell you a little more about it.

It takes lot of work to get a piece of cold, compact, and poorly drained land in proper condition to work. It has to be done late in the season, and is then very poorly done. Proper drainage prevents water standing in the low places on the farm, and will thus prevent the land from becoming sour, and, of course, unproductive. When we have plenty of drainage we can easily put the soil in perfect condition as to porosity, deepness, and pulverization, and these enable us to resist drouth as well as floods. When the soil is in good condition, made so by thorough drainage, as soon as the seed is put into the ground it takes deep root, and obtains more moisture and food, and is consequently a more finished product. I say again that you cannot reclaim a worn-out soil until you have perfect drainage, either surface or tiling. It is absolutely necessary, and it cannot be impressed too much upon any one desiring to obtain the best results.

The ancients understood the importance of drainage, and practiced it. Marcus Porcius Cato died one hundred and forty-nine years before the Christian Era, and in his work, "De Re Rustica," he said, in regard to drainage, as follows:

"If the land is wet, it should be drained with trough-shaped ditches dug three feet wide at the surface, and one foot at the bottom and four feet deep. Blind these ditches with rock. If you have no rock, then fill them with green willow poles braced crosswise. If you have no poles, fill them with fagots. Then dig lateral trenches three feet deep and four feet wide in such way that the water will flow from the trenches into the ditches.

"In the winter, surface water should be drained off the fields. On hillsides courses should be kept clear for the water to flow off. During the rainy season at the beginning of autumn is the greatest risk from water. When it begins to rain all the hands should go out with picks and shovels and clear out the drains so that the water may flow off into the roads and the crops be protected."

The old Roman Senator understood the importance of drainage and practiced it. He was anxious for all to know its worth, as well as other things which he wrote in his treatise. This was the first work on agriculture written in Latin, and indeed it is the first book written in that vernacular at all, and it has more than an antiquarian interest.

The quotation which I have given you was taken from the translation made by Mr. Fairfax Harrison, a dignified Virginia farmer, and now President of the Monon Railroad. He is a scholarly and able man, and it would pay you to get the translation and read it. I tell you the ancients were not such big fools as we sometimes think them to be. Mr. Harrison says in his note on the book, page 13, in regard to some of their methods, as follows:

"In fact, we are just beginning to learn again the value of some of the things Cato practiced. For example, he taught intense cultivation, the use of leguminous plants for soil improvement, the importance of live stock in a system of general farming, and the effective preservation of manure. Barring some developments of bacterial science like the ingenious 'nodular hypothesis' in respect to legumes, the student of farm management to-day could not go far wrong if he founded modern instances of agricultural experience upon the wise saws of this sturdy old heathen."

But I am digressing. Saunders, we were talking about drainage, and I am going to show you some of the reasons I think it so important. Let us take a walk over to the far side of the field, where we have not had the time to complete the ditches. Along here we have it well drained, and you see the fine condition of the land and the growth of the cow-peas. It is very luxuriant. Now here is the place where we have not drained at all. You see the land is heavy, it has no life in it, the color is bad. I do not believe it would raise five bushels of corn to the acre. Look over there at about three acres of land belonging to Mr. Finley. It is white, heavy, and useless. He has been digging a big drain and it will soon be completely drained, and then, in my opinion, it will be the best land on his farm. It will more than pay for itself the first year. There is no humus in it now, and what has been, has been leached out by water; the nitrogen and phosphorus are all gone. I would like for you to see it this time next year, and you would be more than surprised at the change, and the crop on it.

Saunders. I see the importance of it sure, and it is best to have good drainage. In some lands, do you not have to have tiling?

Drenan. Yes. I owned a farm once on Shepherdsville Turnpike and it was level land and it was tiled. The land was very productive after it was tiled, and the possibilities of the place were indeed wonderful. If you have tiling, it is best to have a large main, and then have the laterals to come to it. I believe that all tiling should be open at both ends if possible and then have manholes in them at different places, so as to let the air in them. This will keep the tiling from filling up and will also give plenty of air to the soil, and this is very necessary. If you have a piece of land which has been run down and wish to build it up, be sure and tile it if possible the very first thing you do. Have your land surveyed topographically, and put in the main tiling where your laterals will have the greatest fall. Rain-water contains some ammonia and nitrogen, and they are carried down in soil and some of it is retained. If the water is permitted to stay in the ground any length of time, the nitrogen goes off in the form of gas. Some of it may remain, but the chances are that it will not, as you

see in the three acres belonging to Mr. Finley, and the other land I have shown you. I tell you, Saunders, the study of the soil is a most fascinating study.

Saunders. It is indeed, and I wish you would give me your ideas as to the origin of soil, and if I have anything to add I will gladly do so.

CHAPTER IV

ORIGIN OF SOIL

Drenan. Geologists say that the earth was at one time a molten mass, and that it gradually cooled, and that the earth's surface was entirely covered by water. Owing to internal pressure, some parts of the crust of the earth emerged from the water, and the surface was at first igneous rocks, composed of silica and alumina, united with variable proportions of oxide of iron, potash, soda, lime, magnesia, and small quantities of other substances. Through the prolonged action of water, air, and frost, these rocks began to disintegrate and to pulverize, and later on, vegetable and animal life and their products affected same, and we have most of the soil of to-day.

Some soils are derived directly from the decomposition of the igneous rocks themselves, as in the case of soils derived from lava, basalt, and granite.

I remember seeing some land in Canada, and in Oregon, which was pulverized lava, upon which vegetation grew luxuriantly. I remember also seeing one tree at Victoria growing upon a big rock without any soil to support. Of course the rock was in such a condition that the roots could get sustenance from it.

Wherever soil exists to-day, is the result of the disintegration of this igneous rock through long geologic ages, deposited on the bottom of the sea, mingled and associated with the remains of vegetable and animal life. Owing to chemical action, these sedimentary deposits became rocks consisting either of sand, clay, or limestone, or a mixture of either of these in various states of condition or aggregation.

The sand is the hardest and most resistant part of the

original rock, and is composed mostly of quartz, besides some felspar, mica, and other minerals.

Clay is a hydrated silicate of aluminum. It is the result of the chemical decomposition of potash or soda felspar. These are decomposed by prolonged action of water containing carbonic acid gas, and in the chemical action the alkalies and a part of the silica are removed, and clay remains. Clay has great tenacity and cementing power. This is owing to a small quantity of hydrated colloid (jelly-like) body, and according to chemistry it is not over 1.5, and remainder of the clay is made up of very fine solid particles.

Lime rock was made from the igneous rock by having the lime and magnesia removed by solution and accumulated in the ocean, and these were precipitated through the agency of vegetable and animal life.

From these, sandstones, clays, and limestone—most all of our present soil—have been produced.

The most powerful chemical factor in soil-making is carbonic acid gas. It is first present in the rain, and when this water enters soil containing vegetable matter it acts to a much greater extent. The solution of water with carbonic acid gas dissolves the carbonates of lime and magnesium and they go off in the drainage water. With the aid of these carbonates, the solution also attacks undecomposed silicates and removes some of the alkalies, salts, and some of the silica which they contain.

When vegetation grows upon land, the chemical agents of decomposition gain in power, the carbonic acid gas is much increased, and they are assisted by humic and vitric acids, and together with the solvent action of plant roots, more soil is made. When this process has continued for ages, and has been undisturbed, it produces a surface soil rich in vegetable matter containing plant food in every available form.

Saunders. From the looks of your farm, you have the sandy soil, the clay, and the limestone.

Drenan. Yes. Where we are standing it is what you might call clay. There is scarcely any lime in it, and very little nitrogen. The soil is also what we might call sour. If we take a piece of litmus paper and put it in some of the

soil after it is moistened, the paper will turn red, showing that there is a great deal of acid in it. Before this soil will produce anything, the acidity must be corrected by an alkali. So I will have to put some lime on it.

Saunders. Let me see that piece of litmus paper. Where did you get it?

CHAPTER V

LITMUS PAPER AND TESTING SOIL

Drenan. Litmus paper is of very delicate vegetable fiber. There are two kinds, red and blue, but we need only the blue. When an acid is put on same, it turns red, and when an alkali is put on it, it turns blue. You saw this paper turn red just a few moments ago. Here is some lime that I am going to put on the land. Now I am going to put some lime on this I have in my hand, so that you can see what influence it has on it. See how it turns blue. The lime has changed it from an acid to an alkali. Let us take some more earth, and not put too much lime in it. Here this litmus paper now is neither red nor blue. It is a neutral. You see it is rather a nice calculation to determine just how much lime to put on, and if it is burnt lime we must be very careful and not put too much. I can tell whether the land has any lime in it by taking some of the earth on a plate and pouring some hydrochloric acid on it. If it effervesces that shows it has lime in it. You have seen the foam on soda water. If this foam arises, we may know that it has some lime in it. If it does not, then we may know that there is no lime in it, and it should have some. If you will walk back to the corn field, I will show you some things about it. Most of the soil on this land is what we might call worn out. I have made inquiries from ny neighbors, and they tell me that for years and years timothy hay was raised and hauled to the market at Louisville and nothing brought back to it in the way of manures. The man who owned it thought it was so very fertile that it could never be exhausted. He did not keep it properly drained, and he carried away the fertility in loads of hay, and year by year it went down, until it no longer paid to

cultivate it. Before it is worth anything its fertility must be restored.

There are so many worn-out farms. It would surprise you to see them. To restore them to such fertility as they might be useful is a great question and concerns every one. A person should hold his land in trust, so to speak, not only for himself but for future generations. When he mistreats it, he is robbing posterity.

Saunders. You have my idea exactly. I do not know the different theories, and cannot talk scientifically about it, but I have always aimed to put more on my land than I take off. I do this in the form of manure. You know I am a trader, and feed quite a number of horses, and it has been my aim to keep my land improved. A man might as well starve his horse and expect him to fatten, as to abuse his land and expect it to smile back.

Drenan. There is an awakening among the people, and our leading citizens are becoming interested in soil restoration. The agricultural schools in the land are doing great work in helping to scientifically understand the subject and the best means to do so. Eminent men of science, statesmen, and wealthy men are doing what they can to blaze the way for soil rejuvenation. It has become one of the big questions of the day. Any man who can show how to raise seventy-five bushels of corn to the acre on worn-out land instead of twenty-five bushels, the average now raised in the United States, would be a great benefactor of the human race. Some men gain imperishable fame by winning great battles, some leave "footprints on the sands of time" by herculean efforts in statecraft, but all citizens of our country and their posterity should gratefully remember the acts of the agricultural hero who teaches and shows how to make the barren desert groan with abundant crops, and the deserted, worn-out farm to again be the garden of plenty, and he is entitled to a monument which corroding time will not destroy. Here we are at the corn field, and I never become tired looking at it.

Saunders. It is fine and all right—tell me something more that you did.

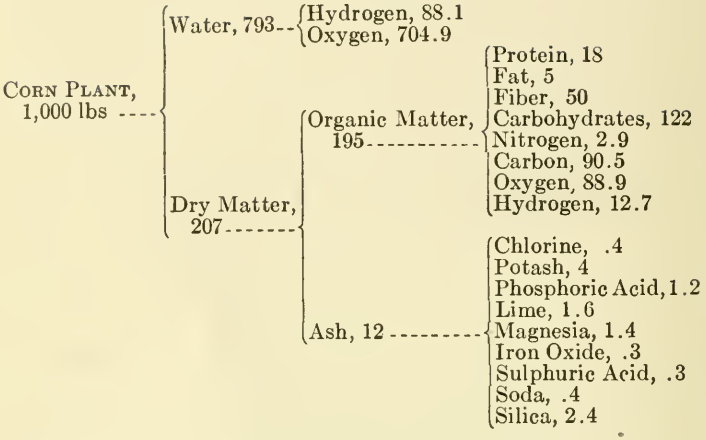
CHAPTER VI

GREEN MANURE

Drenan. After the thorough draining that I gave the field, I had turned under all the vegetation that it had upon it. It had grown up in broom sage, and was a sorry sight. This grass made a good coating of manure, and I had it disked several times, so as to have it pulverized as much as possible. It was then sown in rye, and the next spring, when the rye had gotten about waist high, it was turned under with a disk plow about nine inches deep. The ground was again disked and redisked several times. It was let alone for about two weeks, to let the rye thoroughly decompose, and was then disked twice. Before disking, about one thousand pounds of burnt lime to an acre was added. It was then planted in corn.

Saunders. I know that turning under a green crop of manure helps the land under certain conditions; I wish you would give me your reasons for doing so. I know it adds fertility.

Drenan. Chemists have analyzed the corn plant, and we know just what elements it contains. All known matter is composed of from seventy to eighty elements. An element is incapable of further division, and is the simplest substance known. Now, corn is composed of thirteen elements, namely, hydrogen, oxygen, nitrogen, carbon, chlorine, potash, phosphorus, lime, magnesia, iron, sulphur, soda, and silica. By the study of chemistry we learn of the characteristics of each. Mr. Vivian gives the analysis of the corn plant as follows:



From this we see that hydrogen, oxygen, and carbon compose 98½ per cent of the whole. Potash, phosphorus, and nitrogen are three elements necessary to make good soil. Of these nitrogen is the most difficult to obtain, and the most costly. It has been said that "nitrogen promotes growth, phosphorus produces fruitfulness and early maturity, and potash increases quality." When a soil has these three elements, with proper cultivation it will produce abundantly.

We see also from the analysis of the corn that it has sulphuric acid, and this, of course, acts upon the hard particles of rock in the soil, the same as it did on the phosphate rock I told you of.

Saunders. Are there any hard particles of rock in a well-pulverized soil?

Drenan. Oh, yes. It would astonish you to take some of the very best pulverized soil we have, and put it under a microscope; you will find small particles of rock. If it is sandy loam, it will be the quartz that I have mentioned. These hard rock have some of the elements of plant life in them, and when the sulphuric acid acts upon them they will become in such a condition that plant life can reach them.

When soil is depleted by constant cultivation it lacks humus, organic matter, and nitrogen. It then becomes necessary to put these back, so that the soil will again produce a good crop.

Saunders. How would you put these back? You say it takes humus, organic matter, and nitrogen. I would like to know what you mean.

Drenan. When vegetation falls to the ground, and has become thoroughly rotted or decomposed, and becomes a part of the soil, it is what is called humus, otherwise it is the residue of decayed organic matter. It is what gives the black appearance to the land. Some soils are blacker than others, and this is because it has more humus in it. Organic matter is vegetable and animal matter incorporated in the soil, like leaves, roots, manure, etc. When this organic matter passes the different stages of decomposition and is fully decayed, it becomes humus. I see over here an old fence-row. It is very fertile. I remember when a boy that my father always cleaned out an old fence-row and would make his tobacco bed in it, because it was the best land on the place. I thought at the time it was because it had rested a long time, and that it had regained its original fertility. What had really happened, weeds and bushes had grown up, and the roots had opened up the soil and caused the air to reach it and supply it with oxygen, and the fence and the weeds and bushes had caught the leaves and other vegetable life and held them to the fence-row, where they decayed and become fully incorporatd in the soil as humus. By humus being repeatedly added to the soil it became richer and richer, until it was really the richest place on the farm. Now what Nature has done for the fence-row, we can do for the whole farm.

A part of the nitrogen is added to the soil by the decayed vegetable or animal matter, and the other is taken from the atmosphere through the work of soil bacteria which make their homes in the root nodules of nitrogen-gathering plants, and which draw the nitrogen from the air and deposit it on the nodules on the roots, and it thus becomes available for plant food. The roots of trees also gather nitrogen and store it in the ground. Clover, cow-peas, and vetch are some of the plants that draw nitrogen from the air and put it on the root nodules as I have mentioned.

For centuries Nature had been storing in this great country of ours plenty of humus and all other elements

necessary to raise abundant crops, and when our forefathers cleared the forest they found the soil rich in humus and with untold millions of friendly bacteria working and ready for centuries more of work. Our forefathers thought the soil inexhaustible, and year after year they continued to cultivate, taking all they could off and returning nothing, abusing the soil in many ways and slaying in ruthless manner the great army of bacterial friends, until now we find the work of destruction so well done that we find it almost impossible to rebuild this mighty fabric. However hard is the task, it can and must be done, and my prediction is that it will come sooner than we expect.

CHAPTER VII

ORGANIC MATTER

Saunders. You have given me your ideas about humus, but you have not told me much about organic matter. I believe you said that depleted soils needed humus, organic matter, and nitrogen. I understand what you mean by humus and also by organic matter. I have always believed that organic matter was more needed in soil than anything else. When I put plenty of good fresh manure and plenty of straw on land, I raise a good crop of corn. When this is not done, I do not raise as good a crop. This shows me that organic matter is very essential.

Drenan. Organic matter is indeed very necessary. Organic matter in time becomes humus. Let us go over to the new piece of land which I have recently had cleared, and if we go, we will find the land rich in humus and also full of organic matter. The leaves have fallen on the land for hundreds of years, and the trees have fallen and the roots have rotted, and the soil contains a large amount of organic matter. The great army of bacteria have done their work well; they have brought nitrogen from the air and deposited it in the soil, and all that is needed now to raise an immense crop is proper cultivation. It is very necessary to have a good supply of moisture to raise a large crop. You know in some places they plow the land deep and pulverize it as much as possible, to prevent evaporation. The land is stirred often during the summer, and this conserves the moisture. Now, if land is full of organic matter, it will hold more moisture. It has been said that a pound of soil with organic matter will hold three times as much water as a pound of clay soil, and will retain it twice as long. This same soil will also contain five times as much

water as the same amount of soil of sand, and will also retain it five times as long. We cannot get too much organic matter into land. Bacteria cannot live on the minerals in the soil. They must have organic matter. As I have said, they reach their highest development in virgin soil. Scientists say, and I believe it is so, that these bacteria are necessary for putting the soil in proper condition for plant growth. In some way they cleanse the soil, and put it in proper condition for plant life. These little workers must have organic matter upon which to live. From this you see that I believe it is very necessary to put into the soil plant life, or organic matter. In my opinion, you can never maintain soil fertility unless you turn under some green crop. You see that forty-acre field on the northwest side of the farm. Last year I let it grow up with wild grass, and it made a dense mat over the whole field. I anticipated that the ground would be very much benefited by turning under this coating of grass. I put the man to plowing it, and left for the city, and upon my return I was amazed to find that he had plowed a few furrows around the field and had then set fire to the grass and had burned it all. I was mad and felt that he should be treated the same way. The only excuse he gave was that it was easier to plow. I am satisfied that there was at least ten dollars' worth of nitrogen, phosphoric acid, and potash to the acre, and all of this went up in smoke. There is simply no excuse for such wanton negligence. Here was a loss of at least five hundred dollars, and besides the land lost the addition of tons of fertility.

Saunders. You said something a little while ago about some crops peculiarly suited for gathering nitrogen from the air and storing it away on the nodules in the roots; I have always understood that rye was about the best crop to turn under, and I understand from you that rye does not gather these bacteria on the rootlets. I believe that rye is an extra good crop to turn under. I have turned this under and found that I had good results.

Drenan. There are two kinds of crops that are useful to turn under. One class adds nothing directly to the soil, and the other does add nitrogen to it. To the first class belong rye, rape, and buckwheat, and to the second class be-

long cow-peas, clover, vetch, and beans. The first class has the power of reaching out and collecting from the soil elements that are needed, and when the roots are turned under and decay, the soil is more suitable for the succeeding crop. When a crop of rye is turned under it adds potash, phosphoric acid, and nitrogen to the soil. Chemists say that in a ton of green rye there are eleven pounds of nitrogen, four and a half pounds of phosphoric acid, and twelve and a half pounds of potash, and it also contains the other elements; and that it produces nitric and carbonic acids, and these act upon the soil in the way I have mentioned. It will produce from five to ten tons to the acre, and you can see at a glance its great value as manure. It is sown and raised at a time of the year when the land is not occupied with other crops. Some writers say that it is better in the long run than manure. My experience is that when I have turned under rye, and then disked and followed with a drag harrow, that I have gotten better results than where it was not turned under. Last year I made a mistake and let the hogs eat it, and I did not have as much rye to turn under as there should have been.

Saunders. Rye is great for the land. I believe people make a mistake in sowing it too late. It should be sowed soon enough to get a good root before winter. By the first of December the field should be covered completely, and look green and healthful.

Drenan. I know you are right. The more roots it has and the longer they are, the more organic matter you will put in the land. By all means never make the mistake I did last year of grazing it in the spring. Let it grow until you get ready to turn it under. It should be turned under so that none of the rye will show, and it should be disked and harrowed well, and the soil at the top should be pulverized as much as possible, and if it could be rolled it would be all the better, so as to prevent the escape of the gases and to make as much of the acids as possible. The rye will soon decompose, and you have a lot of organic matter to feed the bacteria in the ground, and for supplying future crops with the necessary maintenance.

One of my neighbors told me last year not to turn under the rye—that it would sour the soil, and that I would not

be able to raise anything. I told him that I had drained the land extra well, and that I did not anticipate any danger from that source. What rye I did turn under aided and assisted, as you see the good crop of corn. I am very enthusiastic about turning under rye, and I believe it will do as much good as anything you can do. I have had much experience with rye, and I have turned under a lot of it and I can safely say that if your land is well drained you need have no fear of it becoming sour. If you turn under a crop of rye, and the land becomes sour, you can depend upon it that the land is not properly drained, and that you had better look after it. I would like to impress upon everybody the importance and necessity of good drainage. Rye is a fine crop to help bring back a worn-out soil to fertility. It costs but little to put it in, it grows rank, and when properly turned under it will aid and assist in holding the moisture.

Saunders. I see you have a lot of cow-peas on the place, and I suppose you are a great believer in them.

Drenan. Yes. You see I have peas planted every place I could find a place to put them. Cow-peas draw nitrogen from the air and store it on the rootlets. I have the corn field sowed in cow-peas and I have the field in the front sowed in cow-peas alone. I am going to turn all of them under. Come out here and we will pull up some cow-peas so you can see the roots. Look at this one; it has some large nodules on it. Analysis shows that these contain innumerable bacteria, and that these bacteria can obtain the nitrogen from the air. The cow-peas, with the assistance of these bacteria, get nitrogen from the air instead of procuring the same from the nitrates in the soil. If the soil is in such condition these bacteria cannot live or do work, the plant will get its supply of nitrogen from the soil, and the nitrogen contents of the soil will therefore be diminished to a certain extent. My observation of the cow-peas, red clover, and vetch is that they will obtain most of their nitrogen from the air, and they are for this reason fine crops for the land. If you are going to turn under any of these crops, you should turn them under while green. They should not be permitted to mature. There is more nitrogen in the green crop than in the ripe one. The no-

dules seem to get smaller as the crop matures, and if your aim is to put all the nitrogen in the land that you can, then it is better to turn under while it is green and just before maturity begins. I fully believe that if a person would take a worn-out piece of land and plow and subsoil well, put on ground limestone, and then put in cow-peas in the spring and turn under in August, and in September put in rye, and in the spring turn under, I am sure a good crop of corn could be raised upon the same that year. If the same process was repeated the second year, I have no doubt as to the next year's crop. It would be a good-sized one, and would perhaps pay for all the trouble.

Saunders. This may be all right, but most men are not able to let their land go idle that long, and to bear this extra expense.

Drenan. Yes, that is true, but they can sow a catch crop and aid and assist in keeping the land in good condition. Suppose a man has ten acres of corn, he can very easily sow cow-peas in it at the last plowing, as I did this corn field behind the house, and when the corn is gathered, plow it under. If wheat is raised, as soon as it is gathered the ground can be broken up and sowed in cow-peas, and when they come to enough growth, be turned and make a good coating. You will not only get an extra amount of humus, but you will aërate the land, and the air will also aid and assist to keep the soil balanced anyway. Going back to what I have repeatedly said about drainage and tiling and plowing, I want to say that they put the ground in ideal condition for the decomposition of organic matter and increase the amount of food available for the crop, but at the same time they do an injury to the soil which should be repaired.

A Minnesota bulletin gives the loss of nitrogen and humus from soil in twenty-three years' cultivation. It is as follows:

LOSS OF NITROGEN AND HUMUS FROM SOIL.

	Native Soil	Cultivated 23 Years
Total humus	3.97	2.59
Total nitrogen	0.36	0.19
Capacity to hold water	62.00	54.00

From this we see that it is best to get busy and renew the nitrogen and humus, and all other elements that may be exhausted or diminished, and as manure cannot be gotten in sufficient quantity, the next best thing to do is to turn under green manure. In fact, I believe it is as good if not better in the long run. Of course, manure is good if it can be gotten, but the problem is to get it in sufficient quantity.

Saunders. I have not heard you say a word about crop rotation. I consider this very important, and I have been taught that the rotation of crops will renew the fertility. I have practiced this in my farming, and I find that it pays.

CHAPTER VIII

CROP ROTATION

Drenan. I believe in rotation of crops and have always practiced it. It evidently increases the yield, but does rotation of crops alone increase fertility? The Agricultural Department at Washington seems to think it will. The Department contends that when a crop is raised continuously on one piece of land, that the excreta from the roots of the plant will poison the ground, and thus prevent or check the growth of the same crop or plant. This has also been the theory of a number of scientific men. They contend that plants have excreta as human beings—that as excreta of the human being is poisonous to human life, likewise is the excreta of the plant poisonous to the same plant. They contend that there is no such thing as soil exhaustion—that it is nothing more than soil poisoning. The Department contends that crop rotation will remedy the evils. Somehow or other I cannot believe it. I am not an expert or scientific agriculturist. I have read and studied a great deal on the subject, but I cannot believe this excreta theory. It seems to me to be too finespun and farfetched. Rotation of crops has been practiced for hundreds of years. No doubt it was at first accidentally discovered, perhaps at first by cultivating the land without raising any crop, and it was discovered that it was good, then perhaps commenced the practice of rotation of different crops for three years and for four years. Rotation of crops, however, does increase the yield. The Rothamsted Experiment Station in England has kept an accurate account of the different experiments, and it has tried all kinds. This is the data furnished by this station:

EFFECT OF ROTATION ON CROP PRODUCTION—AVERAGE OF EIGHT COURSES, THIRTY-TWO YEARS.

	Bushels per Acre.	
	Barley	Wheat
Grown continuously	18	12
In rotation	32	26

This evidently shows that rotation increases yield, and hence we cannot help but come to the conclusion that rotation is necessary. Somehow or other that excreta theory upsets me. It does not look reasonable. I know that the roots of corn are different from those of wheat; the root of the alfalfa is different from the root of rye. Some roots go deep into the ground and get their sustenance from the lower surface; some roots are maintained near the surface. The chemical elements are in different proportions in different plants. As deep-rooted plants get their food deep in the ground, they perhaps bring up food near the surface which is not consumed, and it thus helps the next crop, provided the next crop is a shallow-rooted plant. It is well known by every one that shallow-rooted plants do better if they follow after the deep-rooted plants.

When one crop is grown continuously on a piece of ground, I have no doubt but that plant diseases peculiar to that plant exist and thrive. Plant diseases are caused by bacteria or other fungi living on that plant. The disease is usually limited to that genus of plant. Take the fungus growth on corn, it will not grow on the cabbage, and what will grow and make a disease on cabbage will not do so on the bean. When a crop is continuously grown year after year, the disease will be carried over and is given every opportunity to exist. When the crop is rotated, there is less liability to carry over this disease. When you grow one crop continuously, there will be certain weeds come up that will not be killed by the cultivation necessary to raise that crop. In rotation, we can have different methods of cultivating, and this will kill the different weeds.

Saunders. I see from what you say that you believe in rotation of crops, but you believe a shallow-rooted plant should follow a deep-rooted one. I have always practiced rotation of crops, and I never gave a thought as to the kind

of rotation it should be. I see at once the necessity of giving more thought and attention to the matter. I wish you would reiterate your ideas and give me the kind of rotation there should be.

Drenan. Red clover, rape, wheat, corn, and rye are deep rooted, and they have great power of obtaining ash constituents from the lower soils. Potatoes, turnips, beans, peas, and onions are shallow rooted, and they get their subsistence from the surface soil. The deep-rooted plant makes the subsoil contribute to general fertility. The air goes deeper and the soil is better aërated, pulverizing goes on better, and the different elements are let go, so to speak.

Saunders. What I want to know is whether you would have two, three, or four year rotation, and what would you put in each year?

Drenan. Corn is a very deep-rooted plant, and if the subsoil is in proper condition it will go down some distance. I would have corn say the first year. In the fall I would disk the corn field with the stalks on it. I would turn it under and sow in rye. In the spring, about the middle of April, I would plow this rye under and pulverize the soil at first with a drag harrow, doing this to keep in the gases. When the rye was decomposed I would disk each way, and put it in as good condition as I could. About the last of May or the first of June I would sow in cow-peas, and when harvested I would sow in wheat, and in the spring I would sow in clover. In this way one can preserve the nitrogen, potash, and phosphoric acid, and get four good crops. He would harvest a crop each year. I would plow under the clover after I harvested the first growth of clover. I would let it grow, after cutting it the first time, until it was beginning to head out before plowing under. It should be plowed under while green, as it has more nitrogen at that time.

The rotation then would be four years—*corn, cow-peas, wheat,* and *clover.* If this method is practiced I have no doubt but that fertility could be maintained and the amount of crops very much increased. If a person wanted to change and have different crops, he could do so. I am going to give you a list of some plants, and the weight and average composition in pounds per acre, and it might be of some use to you. They are as follows:

THE WEIGHT AND AVERAGE COMPOSITION OF ORDINARY CROPS IN POUNDS PER ACRE.

	Weight of Crop		Total Pure Ash	Nitrogen	Sulphur	Potash	Soda	Lime	Magnesia	Phosphoric Acid	Chlorine	Silica
	At Harvest	Dry										
	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.
WHEAT, grain, 30 bushels	1,800	1,530	30	34	2.7	9.3	0.6	1.0	3.6	14.2	0.1	0.6
" straw	3,158	2,653	142	16	5.1	19.5	2.0	8.2	3.5	6.9	2.4	96.3
Total crop	4,958	4,183	172	50	7.8	28.8	2.6	9.2	7.1	21.1	2.5	96.9
BARLEY, grain, 40 bushels	2,080	1,747	46	35	2.9	9.8	1.1	1.2	4.0	16.0	0.5	11.8
" straw	2,447	2,080	111	14	3.2	25.9	3.9	8.0	2.9	4.7	3.6	56.8
Total crop	4,527	3,827	157	49	6.1	35.7	5.0	9.2	6.9	20.7	4.1	68.6
OATS, grain, 45 bushels	1,890	1,625	51	34	3.2	9.1	0.8	1.8	3.6	13.0	0.5	19.9
" straw	2,835	2,353	140	18	4.8	37.0	4.6	9.8	5.1	6.4	6.1	65.4
Total crop	4,725	3,978	191	52	8.0	46.1	5.4	11.6	8.7	19.4	6.6	85.3
MAIZE, grain, 30 bushels	1,680	1,500	22	28	1.8	6.5	0.2	0.5	3.4	10.0	0.2	0.5
" stalks, etc	2,208	1,877	99	15	------	29.8	------	------	------	8.0	------	------
Total crop	3,888	3,377	121	43	------	36.3	------	------	------	18.0	------	------

THE WEIGHT AND AVERAGE COMPOSITION OF ORDINARY CROPS IN POUNDS PER ACRE—*Continued.*

	Weight of Crop		Total Pure Ash	Nitrogen	Sulphur	Potash	Soda	Lime	Magnesia	Phosphoric Acid	Chlorine	Silica
	At Harvest	Dry										
	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.
MEADOW HAY, 1½ tons	3,360	2,822	203	49	5.7	50.9	9.2	32.1	14.4	12.3	14.6	56.9
RED CLOVER HAY, 2 tons	4,480	3,763	258	98	9.4	83.4	5.1	90.1	28.2	24.9	9.8	7.0
BEANS, grain, 30 bushels	1,920	1,613	58	78	4.4	24.3	0.6	2.9	4.2	22.8	1.1	0.4
" straw	2,240	1,848	99	29	4.9	42.8	1.7	26.3	5.7	6.3	4.3	6.9
Total crop	4,160	3,461	157	107	9.3	67.1	2.3	29.2	9.9	29.1	5.4	7.3
TURNIPS, root, 17 tons	38,080	3,126	218	61	15.2	108.6	17.0	25.5	5.7	22.4	10.9	2.6
" leaf, "	11,424	1,531	146	49	5.7	40.2	7.5	48.5	3.8	10.7	11.2	5.1
Total crop	49,504	4,657	364	110	20.9	148.8	24.5	74.0	9.5	33.1	22.1	7.7
SWEDES, root, 14 tons	31,360	3,349	163	70	14.6	63.3	22.8	19.7	6.8	16.9	6.8	3.1
" leaf, "	4,704	706	75	28	3.2	16.4	9.2	22.7	2.4	4.8	8.3	3.6
Total crop	36,064	4,055	238	98	17.8*	79.7	32.0	42.4	9.2	21.7	15.1	6.7

*Calculated from a single analysis only.

THE WEIGHT AND AVERAGE COMPOSITION OF ORDINARY CROPS IN POUNDS PER ACRE—*Continued.*

	Weight of Crop		Total Pure Ash	Nitrogen	Sulphur	Potash	Soda	Lime	Magnesia	Phosphoric Acid	Chlorine	Silica
	At Harvest	Dry										
	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.
MANGELS, root, 22 tons	49,280	5,914	426	98	4.9	222.8	69.4	15.9	18.3	36.4	42.5	8.7
" leaf, "	18,233	1,654	254	51	9.1	77.9	49.3	27.0	24.2	16.5	40.6	9.2
Total crop	67,513	7,568	680	149	14.0	300.7	118.7	42.9	42.5	52.9	83.1	17.9
POTATOES, tubers, 6 tons	13,440	3,360	127	46	2.7	76.5	3.8	3.4	6.3	21.5	4.4	2.6
BEECH, wood	------	2,822	26	10	------	4.2	0.8	12.9	3.4	1.5	------	2.2
" leaf litter	------	2,975	166	39	------	8.8	1.6	73.1	10.9	9.3	------	53.9
Total produce	------	5,797	192	49	------	13.0	2.4	86.0	14.3	10.8	------	56.1
SPRUCE FIR, wood	------	3,064	20	------	------	3.6	0.4	8.2	1.8	1.3	------	2.9
" " leaf litter	------	2,683	121	------	------	4.3	1.5	54.4	6.2	5.7	------	44.3
Total produce	------	5,747	141	------	------	7.9	1.9	62.6	8.0	7.0	------	47.2
SCOTCH PINE, wood	------	2,884	15	------	------	2.3	0.2	9.0	1.5	1.0	------	0.5
" " leaf litter	------	2,845	42	------	------	4.3	1.7	16.8	4.3	3.3	------	5.8
Total produce	------	5,729	57	------	------	6.6	1.9	25.8	5.8	4.3	------	6.3

When these analyses are studied, you can see what is taken out by the different crops and what should be restored. If you will look at the red clover hay, assuming that there are two tons to the acre, there are 258 pounds of pure ash, 98 pounds of nitrogen, 83.4 pounds of potash, 90 pounds of lime, and 24.9 pounds of phosphoric acid. When red clover is turned under, it adds greatly to fertility. When it is hauled off the land, we see also what the land loses. Clover helps the land even if both crops are removed, because it gathers nitrogen from the air as cowpeas, and is considered the best for this purpose.

Saunders. As I am a trader and have horses and stock, they make a great deal of manure, and I help to maintain the fertility of my farm by applying it. This is no doubt a good way, and I believe it is the best for restoring fertility. I have noticed the effect of manure for several years. It certainly helps the soil and no doubt greatly benefits it. A good dairyman nearly always has a rich farm.

CHAPTER IX

MANURE

Drenan. That is so. I want to take you over to see a neighbor of mine by the name of Finley. He has a dairy of ninety cows, and I consider it one of the best I ever saw. The plant is not one of those imposing ones you see in New Jersey just before you get to New York. I believe he has more common sense mixed up with it, and good judgment in it, than you will find any place. I want to take you over to see him and meet his family. He has a most excellent wife, a young son, and two little daughters that are very bright and happy. We can go over and see him before dinner, and by the time we get back Mrs. Drenan will have dinner, and I want you to see her fine pantry of preserved fruits and canned goods. She has a fine lot, and I am as proud of them as she is. Here is your hat, we will drive over. In going over, I can show you the alfalfa field.

Saunders. Is this your alfalfa field? It looks very thin, and I would not think you would get much hay off of it.

Drenan. You are right, it is a little thin. You know the soil had to be inoculated with the alfalfa germ. I got some and sowed a part myself to show my tenant how to sow it. When I left, he said that I did not have any sense any way, and that he was not going to spend the time sowing it. He took it back to the crib, and I found it there this spring. Where you see the alfalfa, that is the place where I sowed the dirt which had the germ in it, and you can see that it is all right, and if the field had been like that it would be good. I got the germs in an old alfalfa field near here. This tenant could not believe it was

necessary, and he did not want to do the work. Of course, I did not know it, or we would then and there have parted company. He was antediluvian and certainly a back number. He was not willing to take the advice of experienced men. This tenant has made a failure in life, and always will be such. I see Mr. Finley at the barn. He is a hard worker and always keeps busy.

Good morning, Mr. Finley. I have here an old friend that I want you to meet. He is a farmer and a trader, and is very much interested in my corn crop and in restoring worn-out land to virgin fertility. I want to make you acquainted with my friend, Mr. Saunders.

Finley. Good morning, Mr. Saunders, I am glad to know you. When did you come down to see the Judge?

Saunders. This morning, and I have been very much interested in his conversations about the growing of corn, his discussions of soils, and how to restore worn-out lands. He is certainly a fine theoretical farmer.

Finley. All of us call him Judge down in this part of the country, and I believe if he had the time to stay on the farm and give it more attention he would be a very successful farmer. As it is, he makes us all sit up and take notice. He certainly has a very fine crop of corn this year, and his potato crop was a bumper. I believe he raised about a thousand bushels on three acres. They were certainly large.

Drenan. I do not take any of the credit for this crop to myself. My foreman, Mr. Moremen, planted it and did all the plowing, and did some things that I did not approve of. He raised the crop, however, and the potatoes brought $2.50 a barrel in the market when other potatoes were bringing $1.65. What I did was done the year before. I cultivated the field well and sowed it in rye, and hogged it down, and had about sixty hogs fattened on the lot. The feed and the manure from these hogs enriched the lot very much. I had two open ditches made through it so the water would go off at once, and not leach out all the nitrogen, potash, and phosphorus I had put in it. Moremen persuaded me to put it in potatoes. I am glad I did, as it paid well, and I learned a great deal about cultivating the crop. I knew nothing about it before this

year. I have been telling Mr. Saunders about your fine barn and cows, and that you had your ideas as to how to restore fertility to worn-out land, and I suggested to him that we come over and see you and talk to you.

Finley. I have given more time and attention to the dairy business than to general farming. When I commenced the certified dairy business, this farm, which then consisted of 125 acres, was worn out. Hay crop after hay crop had been carried off to the city of Louisville, and but little manure had been returned. The fertility decreased and kept on decreasing, and something had to be done. Farming was no longer profitable. I disliked the general dairy business, as it was very much abused. Dirty milk was sold, and I felt that many a death had been caused by it. When the opportunity came to me to sell certified milk by having healthful cows free from tuberculosis and other diseases, and the milk handled in a sanitary manner, I took advantage of it, and have been in the business for several years. While it has its ups and downs, and the work is hard and exacting, with the aid and assistance of my family I have kept on, and I have at last a very good business. Come into the barn, and I will show it to you. You see here is where we milk the cows. This part is 60 feet long by 60 feet wide. The floor is made of concrete, and is thoroughly cleaned every day. If I were going to build another, I would not have any loft above it. After the cattle are milked they go back to the feeding barn, which is 224 feet long by 87 feet wide. The feeding trough is in the center. There is a concrete walk in the center, upon which we go to feed the cows, and the troughs are on each side of it. Each cow knows her place and goes to it. When they are through eating they are released; then they walk around in the barn. They sleep in it. I keep the ground-space well filled with straw, and the cattle tramp it, and I put more straw on it about every two weeks. You see there is a big ventilator in it. The cows keep clean, and there is not the least smell in the barn.

Saunders. I see that everything looks clean and neat, and there is no odor in the barn. This strikes me very forcibly. I suppose that your cows make a large amount

of manure? You must have a tremendous amount to haul out.

Finley. I suppose that we haul out every year about a thousand wagon-loads. I have a manure-spreader, and we put it on the land with it. It is a great machine. I do not see how any farmer can do without it. I maintain the fertility of my soil with manure. Judge induced me to sow rye in the front field and turn it under and put in corn. He says I made the mistake of pasturing it down in the spring. I expect he is right, but at that time I had to have some green feed for my cows, and was almost necessarily compelled to pasture it. I will try and not do so another year.

Saunders. I see at a glance that you save all the manure which is made in your barn. I have learned that liquid manure is worth more than solid manure. All the liquid manure made by your cows is saved by being absorbed in the straw. It seems to me that you have the correct theory. I would like to know what Drenan, our scientific corn-raiser, has to say about it. Have you thought much about it, Drenan?

Drenan. Yes, I have. I have read and thought about how best to make and preserve it and to reap the benefits. If there was enough manure in the world to sufficiently spread upon land, the problem of fertility would be easily solved. Unfortunately there is not. What manure is made should be handled to the best advantage. Barnyard manure is the oldest as well as the most popular way of fertilizing land. Cato said, "Plan to have a big compost heap and take the best of care of the manure. When it is hauled out see that it is well rotted and spread. The autumn is the time to do this." Manure has been used ever since by all good farmers. Young stock make less manure than old stock. The young are growing, and the food goes to make bone, muscle, and growth. Practically all the food eaten by a mature cow makes the same amount of manure. Some of the food goes to milk, but practically all of it to manure. Manure is valuable for the amount of nitrogen, phosphoric acid, and potash that it contains. Chemists by repeated experiments have proven beyond doubt that manure has the greatest value at the time it

leaves the animal. If the manure could be put on the land at this time and plowed under, there would be a maximum yield. Most farmers pay but very little attention to liquid manure, as I have said before. The analysis by scientific men shows that it contains more than one-half of the nitrogen and potash. One writer says, "It is perfectly safe to say, however, that of the total fertilizing materials found in the manure, two-thirds of the nitrogen and four-fifths of the potash are found in the urine, but practically none of phosphoric acid."

As soon as manure is made, fermentation in different ways begins. This fermentation is caused by the action of different forms of bacteria. Some of these bacteria can only work and live in the presence of oxygen, and they are called "aërobic" bacteria; the other kind do not require oxygen, and they are called "anaërobic" bacteria. The hot fermentation is caused by the aërobic bacteria. The nitrogenous substance in the urine commences a rapid decomposition, and we can tell it by the odor of ammonia given off, which we can usually detect in the stable. The nitrogen is very quickly given off, and loss therefore occurs. If there is bedding in the stable that will absorb the urine, fermentation is delayed and the greater part of the nitrogen is saved. Some straw is better than other straw; oat straw is better than wheat straw. The shorter the straw the quicker it will absorb the liquid. It is easier for the liquid to come in contact with each and every part of the litter when it is short than when it is long. If a person would take the time to cut all his bedding on a cutting-box, and have it as short as possible, it would pay for the time and trouble. When there is much litter like in Mr. Finley's barn, the liquid manure is readily taken up, and the walking of the cows over the straw makes it firm and keeps out the oxygen as much as possible, and fermentation is retarded. There is no odor given off, and the elements are preserved. The aërobic bacteria do not have a chance to get in their work.

Saunders. I have heard it said, Drenan, that when you were a young boy with your grandmother, that you threw all the manure out of the stable into the barn lot and let it stay there until the next spring, and then hauled

it out. I believe one man told me that he had told you it was not right and that you should not do it, and that you told him that he had better go and attend to his own business and not meddle with other people's; did this happen?

Drenan. I expect it did, and more beside. That was not my thinking age. I was perhaps passing through the same stage that all boys pass, and was not willing to be guided by any one. I remember that I threw the manure out the window in the barn, and it stayed out in the rain and snow all winter. I can well remember the heap smoking and becoming very hot and dry. I did not know at the time that the nitrogen was passing away, and that it was being very much deteriorated. I well remember how white or "fire-fanged" it became. I expect in truth that I did not care. Since then, life has been real, and I have tried to do some thinking and acting. I can see now that a great waste was going on, and if my education in chemistry had been anything I might have worked out some problems.

When manure is consolidated by tramping like that in Mr. Finley's barn, the air is excluded and the mass ferments but very little; there is a slight rise in temperature, and a small percentage of carbonic acid, hydrogen, and nitrogen is given off, the loss of weight is not so much, and the mass is being converted into humic matter. The fermentation that takes place here is the work of the anaërobic bacteria.

It is said that where rapid decomposition takes place the nitrogen not only disappears but the remaining substance is not so good for plant life; insoluble compounds are produced, and they are not so immediately available for plant food as they were when the excrement was first voided.

Finley. I believe that the loss can be prevented to some extent by sprinkling the manure with gypsum or land-plaster. I have heard it said that when gypsum is spread over manure that it brings about a chemical change that converts the ammonia into a compound that is not volatile, and that it will not pass off into the air, and that the gypsum not only increases the value of the manure but it also increases in value in and of itself.

I believe that dry earth will also help to preserve its value. I know the value of manure, and I try to get the benefit of it in every way I can. The farm here was once poor in fertility, but it is now becoming very fertile. Here is an acre of corn below the barn that I do not believe can be beaten even by the eight-acre field belonging to the Judge. It takes rich and fertile land to produce a big crop. It takes about as much labor on poor land as it does on rich land, and you get more returns from the rich than from the poor land. I believe that by selling certified milk I am doing my fellowman a benefit, and I am helping future generations by bettering the land that I now hold in trust for them. I do not want to be a soil-robber any more than I want to be a money-robber.

Saunders. I see that you are well posted and up with the times. I am not surprised that you have such a good dairy, and my prediction is that it is going to be still better and better as time goes on. Drenan told me of your progressive ideas before we reached here, and I am more than delighted in the trip over, but there is one more question that I want to ask you. I have been told that the value of manure depends upon the feed that is fed; now what can you tell me about that?

Finley. The value of the manure depends upon the feed. If the feed is rich in nitrogen, potash, and phosphoric acid, the manure will also be rich and more valuable. I have a table in my pocket showing the dry matter and the fertilizing constituents in a thousand pounds of the different materials.

	Dry Matter, Pounds.	Nitrogen, Pounds.	Phosphoric, Pounds.	Potash, Pounds.
Cornmeal	871	15.8	6.3	4.0
Oats	889	18.6	7.7	5.9
Bran	883	26.7	28.9	16.1
Clover	887	20.7	3.8	22.0

From this you see that bran is the highest in nitrogen and phosphoric acid, and that clover is the highest in potash and the next highest in nitrogen. Oats are higher in nitrogen than corn meal. I feed a great deal of bran and clover. Alfalfa is high in nitrogen and potash, and I am beginning to feed more and more of it every year. I consider alfalfa one of the very best of feeds.

Saunders. Your figures convince me at once, and I am glad you have shown them to me. You know I am a trader, and I like to trade if I am bettering my condition. If I were to sell two thousand pounds of shelled corn and buy with the same money two thousand pounds of bran, and feed the bran, I would be getting more nitrogen, phosphoric acid, and potash, and thus my stock would make better manure. Of course, if I wanted to fatten the stock I would not want to make the exchange. Am I thinking right, Mr. Finley?

Finley. I believe you are. The figures I have given you are chemical analyses, and my limited experience bears them out.

Drenan. It is nearly dinner-time, and I expect we had better go back home. By the time we get there, dinner will be ready.

Saunders. I want to thank you, Mr. Finley, for showing me around your place, and I hope that the next time I come down to visit Drenan we can see you feeding and milking your cows, and I can then see the practical side.

Drenan. Good-morning, Mr. Finley; you and your family come over to see us.

Saunders. Good-morning, Mr. Finley. If you are ever in Fleming County be sure and come to see me, and I will show you horses and mules, and how I farm.

Drenan. This dirt road you see here has just been graded by the road overseer, and is not in as good condition as I would like to see it. You see that it is graded up high and well drained, and when it settles it will make a good road. I understand that they are going to put a pike here next year. Jefferson County has good roads, and the county officials are doing the best they can to make them good. In my opinion, nothing benefits a community more than good roads. Lands increase in value, and the community at large is much benefited. I wish I had the time to take you all over the county and show you the fine roads we have. You would be much pleased.

Saunders. I learned some valuable things while talking to you and Mr. Finley—that manure from animals is most valuable when it is first voided; that the liquid manure is more valuable than the dry; that fermentation

must be kept down to save as much of the nitrogen, potash, and phosphoric acid as we can; that this can be done by having plenty of short, dry bedding that will absorb the liquid manure; that it must be compacted as much as possible to prevent the escape of the volatile gases; that the quality of the manure depends upon the kind of food that is eaten; that if the food is rich in nitrogen, the manure will be rich; that it is best to spread the manure on the land as soon as possible, and with a manure-spreader. I was impressed by a number of other things that were said, and which will be useful in the future.

Drenan. Here is a field of cow-peas, and the growth is very rank and heavy. I am going to turn them under as green manure. I took a great deal of pains to have this field properly plowed. You know plowing the land properly is all-important.

CHAPTER X.

PLOWING

Saunders. Yes, it is. I know that when I plow my land as it should be done, I get good results. It is a serious question as to the best way to plow. Some believe in deep plowing, and others do not. Some use the old-fashioned turn plow, and others believe in the disk plow and not too deep plowing. As for me, I believe in a deep seed-bed. I do not think the bottom should be turned to the top, but the top of the soil should be turned, and then a plow should run in the same furrow and the bottom plowed up either by a disk or a turning plow. What are your ideas, Drenan? I have been permitting you to tell your opinion first, but I am venturing now to express mine before you do yours.

Drenan. I have thought, read, and observed much in regard to the best way to plow. I believe the closer we follow Nature, the better we are. Nature sends down into the soil deep roots of trees and plants, to open the way for the air to penetrate. They aid to pulverize the soil and to put it in proper condition for plants to flourish. Another thing is, the soil at the surface is usually richer in nitrogen and humus. If you should plow too deep and turn up the soil, say twelve inches, and turn the soil completely upside down, you will put the richest soil too deep; you shut out the oxygen, and perhaps the plant roots would not reach the humus. Now I have a plow which I bought from a manufacturing plant near here, and it is an extra good plow, but however careful I am, I cannot help having some of the lower soil get to the top of the ground. This plow that I have is a turning plow. This plow is carried through the ground with force, and it compresses the earth

and makes the bottom of the furrow very smooth. This pressing of the soil together interferes with soil ventilation and soil temperature. The hydrated colloid which I told you about in clay is pressed closer together, and the soil becomes more impervious to penetration by plant roots. Ever since I have owned a farm, I have always thought the sulky turning plow was one of the best ever made, and I have often said I would not swap it for any I ever saw. I have changed my mind since seeing the different plows in this part of the country. Our neighbor, Mr. Finley, has a double disk plow and it does fine work, and one man can do the work of two. The plow he uses is manufactured by Long & Allsatter, Hamilton, Ohio. I have watched it work, and I want to say to you that it is a good one. There is much to be said about a disk plow. Somehow or other I have had a prejudice against them. Why I should have had it, I am unable to say. My belief now is, after seeing them work, that disk plows are not only the best but really the only kind to use.

The disk plow just breaks off the soil from the soil below, and there is not that pressing together of soil grains nor is there that slick bottom in the furrow. The soil is thus better aërated and pulverized, and it is easier for the plant roots to go through. Plant roots are not confined merely to taking up ready-formed solutions: they are able to attack some of the solid ingredients in the soil and appropriate them. The root-hairs come in contact with these hard and solid parts and they secrete an acid sap, in the nature of carbonic acid, that makes the solid part soluble, and the plant thus appropriates it. The disk plow puts the ground in proper condition so that this change can take place. I intend to have nothing but disk plows on the place as soon as I am able to buy them.

Plowing the soil and getting it ready for the seed-bed is all-important.

Saunders. You have said nothing in regard to deep plowing. I am a firm believer in deep plowing, and I have had remarkable success with it.

Drenan. From what I have seen, I am also a believer in deep plowing. One of my neighbors by the name of Moreman has a plow that is a wonder. It is a double disk,

and is so constructed that one disk follows another. The front disk will plow to the depth that you want, and the rear disk will also plow to the depth you want. The rear one goes in the same furrow and cuts it deeper. This is not turned on top, and is in the bottom, of the furrow. I believe you can plow from eighteen to twenty inches deep with this plow. It is known as the Spalding Deep Tilling Plow, and is manufactured by the Gale Manufacturing Company, Albion, Michigan. I saw a field turned with this plow and I never saw better work, and the crop on the field this year shows for itself. It is certainly a very fine field of corn. This is the kind of a plow to use, and it is a wonder that more of them are not used. I have given the name, so if you want to send for a catalogue you can do so. It will pay you to investigate the matter. You thus increase the depth of the seed-bed by deep plowing, and have the other beneficial attendants that I have mentioned.

The old Romans practiced deep plowing, and much plowing. The learned Cato said: "What is the first principle of good agriculture? To plow well. What is the second? To plow again; and the third is to manure."

The Flemish farmers were great producers, and they plowed deep; the English farmers in England plow deep. It is claimed that deep plowing has been the foundation for the restoration of the fertility of the soil, which had been depleted. Some men have told me of the wonderful things accomplished by deep plowing in the preparation of the seed-bed. One man told me that he had never been able to raise anything until he had plowed very deep. He said that the soil had been opened up and new life had come into it. I am prepared to believe it. It should be practiced on heavy clay soils especially. I believe we should proceed with judgment in this, as in all other matters.

Saunders. Some people think the fertility of the soil can be increased by constant cultivation, and claim if the soil could be broken up several times during the year it would be very much benefited. My idea is, you must have organic matter to make humus, and if you have constant cultivation you will not have it. It is my understanding that there is more potash and phosphoric acid in the subsoil than in the surface, and if this is so, the ground should

be broken about eight or nine inches with a good turning plow, so that the soil would be turned upside down. This would enable the elements to go again into the soil where there is more nitrogen. Turn it up again the next spring, and you have a better distribution of the elements and a better crop to follow. The plow you have is manufactured in Louisville, and is an extra good one. I think it one of the best makes on the market. I have used it for a number of years. The disk plow may be good, but in my opinion the turning plow is the better. I have raised some big corn crops with it, and you know I am almost a Missourian, and "you must *show me.*" Your present corn crop proves what can be done with the turning plow. When you beat it with a disk plow, let me know; I want to see it.

Drenan. You may be right, Saunders. I intend to experiment some next year, and I will let you know the results. Your reasoning about the potash and phosphoric acid going to the surface soil when it is completely turned, impresses me, and I intend to do some investigation. I know you are an experienced farmer and have been very successful, and success is what counts. I have no pride of opinion about anything I have said. My only aim and object is to arrive at correct results. I am in a position now to see what can be done, by watching my neighbors and experimenting myself.

Here we are at home. I see dinner is ready, and I know Mrs. Drenan will enjoy very much having you with us. Mrs. Drenan, here is our old friend, Mr. Saunders. He will be with us for dinner.

Mrs. Drenan. Good morning, Mr. Saunders, how do you do? I am so glad to see you. It has been some time since I saw you. How is your family?

Saunders. They are all well. I am glad to see you looking so well. The last time I saw you, you did not look in good health.

Mrs. Drenan. I lived then in Louisville. Some way or other I contracted typhoid fever, and came near dying. Since my recovery I have been in better health. I have been out here in the country breathing this fresh air and eating fresh food, and I feel so much better.

CHAPTER XI

DINNER AND CANNED GOODS

Saunders. I am certainly glad to see you looking so well. I have enjoyed the morning very much with Mr. Drenan, and it is a great pleasure to see you and him once again.

Mrs. Drenan. Mr. Drenan and I have often talked of you. He is very devoted to you. You were one of his early clients, and you helped and encouraged him. He has never forgotten it. I don't believe there is any obstacle so high that it would prevent his coming to you, if you needed him.

Saunders. You know, Mr. Drenan and I have been friends for a long time; he has been my confidential lawyer, and we have fought a number of battles together, and I am glad to say we have had good luck.

Mrs. Drenan. By complimenting Mr. Drenan, I see you know how to please me. Whoever is Mr. Drenan's friend is also my friend. Well, dinner is ready; come in, all of you. Mr. Saunders, you will please take this seat on my right. I am not going to let Mr. Drenan monopolize all your time. I want to hear more about the good people of Fleming County.

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Saunders. I saw in the Fleming County Gazette that you had taken the premium on a lot of canned goods at the State Fair this year, and that your daughter, Mary, had taken the prize on some cake. I want to congratulate both of you.

Mrs. Drenan. Yes, I received a premium on canned corn on the cob, one on canned tomatoes, one on canned cherries, one on pepper relish, and one on beans.

Saunders. Five! I want to congratulate you again. You say canned corn on the cob? That is something new, is it not?

Mrs. Drenan. Yes; the process is easy, simple, and complete. Mr. Drenan saw some Economy jars somewhere in his travels, and after hearing a lecture in regard to them he purchased a lot and brought them home. I was a little skeptical at first, but since using them I find the Economy jar perfect in every detail.

Drenan. Now don't forget to tell, Mrs. Drenan, how you were finally and fully convinced. If she doesn't tell it, I will.

Mrs. Drenan. My husband thinks he has such a fine joke on me, I am not going to deprive him of the pleasure of telling it.

Drenan. We had been out to the Pacific Coast on a vacation, and had started back home. Mrs. Drenan, Mary, and I were sitting in a dining car of the Northern Pacific, looking at the beautiful scenery as we were crossing the Rockies. We had just finished eating dinner, and we had had as part of the dinner corn on the cob. Mrs. Drenan remarked that it was as fine corn as she had ever eaten, "sweet, delicious, and fresh." I never saw any one enjoy eating corn from the cob any more than she did. She made her remarks more emphatic by saying she did not see why the farmers in Kentucky could not raise as good corn for eating as they do in California. I believe she really wanted me to buy a barrel of it and bring it home with me. About the time she was praising so much the freshness and fine condition of the corn, I saw a twinkle in the eye of the master of the dining car, and I came immediately to the conclusion that it was canned in "Economy jars." So I said to her, this corn was perhaps raised in Kentucky or Illinois, and that I believed it was put up in "Economy jars." She said, "Oh, no. It is impossible. It must have been raised in California, and it was no doubt plucked yesterday. It is too fresh and sweet for canned corn. Impossible to be canned corn!" After talking in this way a little longer, the old proverbial phrase was used, "I bet you it is not canned corn," and I answered back, "I bet you it is canned corn!"

We called finally to the master of the diner and he came, and after telling him the difference of opinion, he told us it was canned corn on the cob, and went to the kitchen and brought us one of the "Economy jars" that had it in. It took, however, the jar with some corn in it to finally convince Mrs. Drenan, and from that time she has been an ardent supporter and user of the "Economy jars."

Mrs. Drenan. I admit I was deceived, and I am glad now I was. It has made me enthusiastic about canning, and I have not been negligent about putting up things. You must see my pantry filled with the different things I have canned.

Saunders. How much canning have you done, Mrs. Drenan?

Mrs. Drenan. I have over one hundred half-gallon jars with corn on the cob, fifty quarts of beans, seventy-five quarts of tomatoes, one hundred quarts of cherries, and quite a lot of others. I think we certainly have enough for winter.

Drenan. It is a fine sight to see them all. When the beans are cooked, you cannot tell them from fresh beans. In fact, I would rather have them.

Saunders. How do you fix the corn when you can it on the cob?

Mrs. Drenan. We get nice good corn and take the silk off it, and have the ear clean in every particular. We then put as many ears in the jar as we can, without bruising them. We then fill the jars with clean water, put on the top, and fix a clamp, which is with the jar, on it. We then put it in a boiler bought from Stahl & Company, Quincy, Illinois. The jars do not rest on the bottom. They rest on rolled tin, and the water can pass under them. The boiler is then filled with water up to the neck of the jars. A top is then placed on the boiler, and it is put on the fire and boiled for five hours continuously from the time it begins to boil. As the water evaporates, boiling water is added to keep the water up to the neck of the jars. When it has boiled the time required, we take out the jars and place them so no draft can reach them, and let them cool gradually. In two days we take off the clamp. The

top is made of a metal which has peculiar qualities. When it is heated it expands, and when cooled it contracts, and makes the jar air-tight. Sometimes a top does not act perfectly. The jar is again boiled, and another top put on it. You soon tell whether the tops fit by tapping them with a piece of metal. Those that make a perfect fit have a peculiar sound, and you can soon learn to tell it. The tops are watched for nine mornings, and if no tops have come off they are set aside as completed. With every dozen cans, there is a booklet which tells of the length of time the different things have to be boiled, and all one has to do is to follow the directions. I do not believe we will have to buy any canned goods this year.

Saunders. I am so glad you have told me about your canning. It seems to me this solves the problem, and that it will be easy for any one to can the different things she wants for the winter, and can thus help to save a large item of expense. Living has become so costly that we have to look ahead and save what we can, and then too we know everything is pure and unadulterated.

Mrs. Drenan. I feel very proud of my pantry. It is not only pretty to look at, but very useful besides.

Drenan. You are not half as proud of it as I am. It is a big saving for me, and your great success in canning has put me to thinking. I believe every man should can his fruits and sell them as finished products, and thus get a big price for them. In the place of selling his cherries by the bucketful he should can them and sell the canned goods; likewise his plums, asparagus, corn, and berries. The successful farmer can do this, and the time is coming when these small manufacturers will play an important part in the economic uplift of the people.

Saunders. I want to say to you, Drenan, you have good ideas, and it is a great pity you can not put all of them into execution. I believe you are a good thinker and a very practical man. Mrs. Drenan has blazed the way for you to become a large manufacturer, and if you do not it is your own fault. Every person has to eat, and you can find a sale for everything.

Mrs. Drenan. I know you men will want to talk politics and business, and if you so desire you can go into the

library, where I know Mr. Drenan will no doubt want to show you the latest additions to it. He seems to prize them very highly.

Drenan. I am going to take Mr. Saunders this afternoon to Louisville in the automobile, and, Mrs. Drenan, we will be more than delighted to have you go with us if you can spare the time.

Mrs. Drenan. I will be more than pleased to go. As I have quite a number of things to look after before I can go, you will excuse my presence. I will try and be ready to suit your convenience.

Drenan. Take this old mission rocker, it is such an easy and comfortable chair. I do not smoke myself, but I keep cigars here for my friends. Here is a Henry Clay; will you have one?

Saunders. No, I thank you, I never smoke. I believe it is not only a bad habit, but very injurious to health. Nicotine is a deadly poison, and I cannot see how any one would want to use it.

Drenan. I was once a constant smoker. I really enjoyed it. It began to affect my heart and I was compelled to stop. It was a struggle, but I have no desire to smoke at all now.

CHAPTER XII

SEED CORN

Saunders. When we were talking this morning, I understood from you that you believed that ground should be plowed deep, and that the seed-bed should be thoroughly pulverized. I believe you are right, and in my opinion a corn crop is half cultivated when the seed-bed is put in proper condition. In addition, I believe we should take the greatest care in selecting seed corn, and we should have the best corn we can get.

You know, Drenan, I am a trader in horses, cattle, hogs, and in fact any live stock. It is my aim to get the best individual and from the best stock that I can. It pays. There is more development and more chances to make money. We get the best colt from the best parents and likewise the best cow and hog. If the theory of evolution is right, we should have the best corn which came from the best. I believe that we do not pay enough attention to these matters.

Drenan. You are right. There is the same reason in the vegetable world for high development as there is in the animal. I want to give you some experience I have had in this line. I had a farm out on Preston Street Road, and had what I considered a good crop of corn. One day I saw a stalk of corn with three ears on it. They were good ears. I saved them and the next year I planted them, and had a number of stalks with three ears on them, and some even had four. I believe we should take the lower ears on the stalk if we want to breed a corn that will produce more. In my opinion, the lower ear is the best. Before it could reproduce itself, there is a probability that it would have to produce the other two ears. The lower ear comes on last, and hence the tendency or at least a probability that

there will be the same number of ears as was on the parent stem. I worked with this in view. I have been breeding the corn you have seen this morning with a view of producing just such results as you see have come about. To my surprise I have the stalk with eight ears on it. They are good ones, and I am going to send you a picture of the corn and the stalk. You see that in the eight-acre field there is hardly a stalk with only one ear on it. They are all either two, three, or four. I have gone over the field and I can't find a single stalk with but one ear on it. I believe this is the result of saving only the seed corn where the stalk had three or more ears on it.

Farmers do not pay enough attention to seed corn. If they went about everything else as they do with corn, there would be very little advancement made. What would you think of a man breeding his fine Duroc sow to a little scrubby mountain boar? We would think he was losing his mind. Yet we think it is all right for him to get his seed corn from a plant which had a dwarf stalk by it. The pollen from the inferior plant fertilizes the stalk of the better plant, and thus we have a weakened production. A farmer usually does not think of the seed corn until the next spring, and then he goes to the crib, if he has any corn in it, or he goes to the nearest seed store and buys what he wants for planting. He does not know the kind, where raised, or its physical condition. No wonder there are so many failures.

Saunders. It would be a good idea for every neighborhood to encourage some specialist in the same to devote some special attention to development of good seed corn. It would be cheaper to give him five dollars per bushel, or even ten dollars. Every farmer cannot specialize in this line, and it would really be to his best interest to encourage and buy at a high price.

Drenan. If you go into a field and notice closely you will be surprised to see the number of barren stalks. It is estimated that these approximate at least 10 to 15 per cent. A good breeder of corn will see that there are no barren stalks in the field, and he will save only good ears and those that conform to the kind he wants. He is always selecting the best and most uniform ear, and only ears that are pro-

duced on strong and vigorous stalks, and he will minimize the effect of inbreeding. If he cannot get corn that has been bred with care, he should look after the seed corn the best he can. He should select the variety he wants, and then watch it and develop it the best he can. I believe the kind to have is a corn that has good-sized kernels, wedge-shaped, with large germ and a medium-sized cob. It should have a well-developed stalk, not too high, and vigorous and extensive root development.

Saunders. Of course, if you have these you will have a good ear.

Drenan. The farmer who is going to select the seed corn from his own field should be certain and cut out all the barren stalks. The pollen from these may injure a lot of his corn. In the first place they are not worth growing, and in the next place they will take some of the strength of the soil, and thus rob the others of it. He should prevent inbreeding as much as possible. He can do this by pulling out the tassels of every other row. This should be done as they are coming out. It will not hurt the stalk, and in fact may do it some good. It has been estimated that upon a well-developed tassel there are between thirty-five to sixty millions of pollen grains. It takes chemical force to produce these, and the same force can go to making larger ears.

Saunders. Then you believe it possible to make corn where there is no inbreeding? This could be done by not having grains of corn off the same cob close to each other, and by detasseling every other hill.

Drenan. There would be some inbreeding, but it would be reduced. It is said that the pollen will fly through the air for at least a quarter of a mile, so there will be some danger of inbreeding. I have noticed that the tassel of some corn matures sooner than silk does on the same stalk. In this case the pollen off the same stalk will not fertilize the silk, and it must be fertilized from some other stalk. I would not be surprised if this is not the way Nature provides against inbreeding. There is no doubt but inbreeding deteriorates the corn.

The Illinois Experiment Station has demonstrated that when corn is inbred the size of the corn diminishes, a weakness develops, and a general deterioration of the vitality

of the stalk takes place. This being the case, we should prevent inbreeding as much as possible.

Saunders. You mentioned a little while ago that the seed corn should grow upon a vigorous stalk. This is certainly right. If you do not want it for silo, the stalk should not be too high. It should be of medium size, and the blades be broad and vigorous. The leaves are the lungs of the plant, and I believe it is of prime importance that they be very healthy.

Drenan. I see from the way you are talking you have given the matter much thought, and that whenever I advance an idea you advance a better one. Without a good stalk and leaves, you will not have much of an ear of corn. The green leaves have on them many chlorophyl cells, and these absorb carbonic acid gas and evolve oxygen. The carbonic acid gas absorbed goes to help the rootlets to put the hard substances into proper condition to help sustain plant life, and performs other useful functions in development. The blades have also on the underside many small openings, known as stomata. When the stalk is well supplied with water, these stomata open; when there is a drouth they close. The evaporation of the water from the leaves through these stomata is most important, and is the principal cause of the rise of the sap, which draws up water from the soil, which contains plant food in solution, and thus causes the corn to grow. In case there is a drouth these stomata close, as I have said, and there is not much evaporation and but little rise in sap, and there can be but little plant food taken from the soil, and hence very little corn is raised. The blades thus perform an important function, and great care should be taken not to break, bruise, or injure any of them. The parent stalk of seed corn should then have broad, vigorous, and healthy blades, and it is very important to see they are such.

Saunders. I know the seed-corn stalk should have extensive root development, but the trouble with me is to know when a stalk has it.

Drenan. I suppose that the size of the stalk, its general appearance, the strength and firmness of the secondary roots, which are sent out from the stalk a short distance above the ground to hold it in position, the general condi-

tion of the ground as to how it is pulverized, and fertility of same.

Saunders. While these things are to be observed carefully, we should watch very carefully how the ear grows from the stalk. It should not have too long a shank, and should when mature bend a little downward. The husks should be firm and long enough to cover well the ear.

Drenan. I believe every farmer should go through his field and select his seed corn before it is cut or gathered. He can select what he thinks to be the best, then tie a cotton string around it, and when the time comes to gather, he can put his selections together, and they can be subject to the further tests he will make before he finally decides which to use.

Saunders. That is a great deal of trouble, but I believe it will repay one.

Drenan. After one has gathered his seed-corn he should make his selections, and put them away in a dry, cool place. I believe it is best to tie them with a string, putting about half a dozen on a string, and then hang them up, in the kind of place I have mentioned.

Saunders. I have done this for several years past, and I know it has more than repaid me for the trouble. In selecting the corn to be used I have paid more attention to the kernel than to the size and shape of the ear. It is the kernel we want. You can have a fine-looking ear and a very poor kernel. However, a good kernel can be found on a typical ear, and it is best to combine all the good qualities if we can.

Drenan. You have extra good ideas, and as they are based upon experience they are certainly worth something. I am glad you came to see me; I have certainly learned a great deal from you. I believe we should have a good ear, and one that conforms to all the requirements of a standard ear. We should pay attention to the shape of the ear, its uniformity, its color, the tips, the butt, the circumference, the length, the ripeness, the kernel shape, the kernel uniformity, the space between the rows, and the proportion of corn to cob. What kind of a shaped ear do you like?

Saunders. I do not like an ear that tapers too quickly from the butt to the tip. I like the ear to be nearly the

same size from the butt to the tip, and round over very rapidly at the tip.

Drenan. A slender ear and one that tapers rapidly is a sure sign of weakness and a lack of constitution. The ears should not taper to a point. We find on such ears that the butt kernels are large and the tip kernels very small, and there would also be a very small percentage of corn to cob. What you want is all the corn you can get. If we could calculate by calculus the maximum amount of corn on a cob we would find that it was on a cob that is about the same size at both ends.

There should be a uniformity in the ears as to size, shape, and general characteristics. Irregularity shows bad judgment in the selection, and is evidence of a very poor breeder. We should notice the indentations on the tops of the kernels, the color and the straightness of the rows. By all means have the rows straight on the cob and parallel with each other. We find so many cobs with the rows of corn winding in a spiral fashion. We should not select this kind.

Saunders. Some people like yellow corn and some like white. I like the yellow corn the better.

Drenan. I do not think there is any difference, so far as the constituent elements of food are concerned. If you have yellow corn, it should have a red cob. If the corn is white, it should have a white cob. Never have yellow corn on a white cob or white corn on a red cob. It is considered a sign of very poor breeding, and if your corn was being judged at the Fair it would be thrown out or stand a very poor show of winning.

The tips should be well rounded and well filled. The failure of the tips to be filled is usually the result of the pollen not reaching the silk. The rounding of the tip shows that the ear has matured evenly and that all the kernels will be fertile. It indicates full maturity, and hence a probability of sure growth when planted.

The butts should be well filled and the kernels should stand out about the shank. When the cob is broken off the shank there should be a small hollow left. We thus get a larger proportion of corn to cob. A cob of corn that has a slightly filled butt, has a large shank and is difficult to

break the cob off it. It is difficult to husk, and this is very undesirable in any kind of corn.

The circumference of the corn should be about three-fourths of the length of the ear. The circumference can be from six and a half inches to seven and a half.

The length of the ear should be at least eight and a half inches. The longer you can get it, and have uniformity of size of cob, the better it is. I have some ears of corn on the field you have seen that are at least twelve inches long. I intend to have an ear at least ten inches long, and three of them on a stalk. If this can be done, I see no reason why one should not raise two hundred bushels of corn to the acre.

When the corn is ripe it is firm, and when a sharp twist is given there is a crisp, rasping sound. When the rows are loose so that you could run a knife down between the kernels, it is a good sign that the ear has not matured. If such an ear should be planted it is probable that a number of the kernels would not sprout, and would be weakling if they did. By all means have the seed corn well matured. There should be no space on the furrows between the rows of kernels, and no space between the kernels near the cob. What we want is the greatest amount of corn on the cob that can be gotten. The more space there is between the rows of corn on the cob the less number of rows there will be on the cob, and the more space there is between the kernels the less number of kernels there will be on the cob. So the spacing should be carefully looked after.

Saunders. You have been talking about shape of the ear, its length, circumference, ripeness, the tips and butts, but what interests me more than anything else is the kernel. What I want is corn. I want the most I can get, or the greatest amount. In my opinion, this can be gotten when the kernel is wedge-shaped. The longer they are the better it is, provided the rows fit closely.

Drenan. You have anticipated me a little. Your observation is very keen, and from what you say you are no doubt an extra good corn-raiser. The cob is a cylinder, or nearly so in the perfect ear. The full ear with the kernels on it is also a cylinder. There is a space between the cob cylinder and the corn cylinder. The cob cylinder being

smaller than the corn cylinder, in order for the kernels to fill this space they have to be wedge-shaped. If they are in other shape, there will be lost space. For instance, say they are more of a square shape, there will be of necessity some space between the rows of corn on the cob, and some space between the kernels on the cob. We see then that the kernels on the perfect ear should be wedge-shaped. I have some pictures of corn that has a perfect ear, and some that has not, and also some pictures of kernels showing what are good and what are not, and I am going to give you some, so you can take them home with you. I find that I can study and learn from a good picture almost as much as if I had the corn to look at. It is better, however, to have the ear or kernels, so you can handle them.

Orange, Judd & Company, of New York, are publishers of some very good agricultural books, and they have framed some rules about corn that are useful to have. I consider them all right. Some corn-growers in the different States have formulated some other rules. These rules have not been formulated very long, and as corn culture has been much considered of late, these rules or others are very useful. I consider them so good that I am going to give you a copy of them:

SCORE CARD FOR CORN AND EXPLANATION OF POINTS

1. Trueness to Type or Breed Characteristics..... 10
   The ten ears of the sample should possess similar or like characteristics and should be true to the variety which they represent.
2. Shape of Ear..... 10
   The shape of the ear should conform to variety type, tapering slightly from butt to tip, but approaching the cylindrical.
3. Color—a. Grain 5
   b. Cob 5
   The color of the grains should be true to variety and free from mixture, with the exception of a few varieties. White corn should have white cobs, yellow corn red cobs.

4. Market Condition (vitality, maturity, etc.)..... 10
The ears should be sound, firm, well matured, and free from mold, rot or insect injuries.
5. Tips 5
The tips of the ears should not be too tapering and should be well filled with regular uniform kernels.
6. Butts 5
The rows of kernels should extend in regular order over the butt, leaving a deep depression when the shank is removed. Open and swelled butts are objectionable.
7. Kernels—a. Uniformity of 10
b. Shape of 5
The kernels should be uniform in size, shape and color, and true to the variety type. The kernels should be so shaped that their edges touch from tip to crown. The germ or chit and the tip portions of the kernels are the richest in protein and oil, and hence of the highest feeding value. For this reason the germ should be large and the tip portion should be full and plump.
8. Length of Ear..... 10
Northern sections 8½ to 9½ inches; central sections 8¾ to 9¾ inches; southern sections 9 to 10 inches.
9. Circumference of Ear..... 5
Northern sections 6½ to 7 inches; central sections 6¾ to 7¼ inches; southern sections 7 to 7½ inches.
10. Space—a. Furrow between rows..... 5
b. Space between kernels at cob..... 5
The furrow between the rows of kernels should be small. Space between kernels near the cob is very objectionable.
11. Proportion of corn to cob..... 10
The proportion of corn to cob is determined by weight. Depth of kernel, size of the cob and maturity affect the proportion.

Total 100

RULES TO BE USED IN JUDGING

1. Length of Ear—The deficiency and excess in length of all ears not conforming to the standard shall be added together, and for every inch thus obtained, a cut of one point shall be made.

2. Circumference of Ear—The deficiency and excess in circumference of all ears not conforming to the standard shall be added together, and for every two inches thus obtained, a cut of one point shall be made. Measure the circumference at one-third the distance from the butt to the tip of the ear.

3. Proportion of Corn to the Cob—Per cent of corn should be from 86 to 87. In determining the proportion of corn to cob weigh and shell every alternate ear in the exhibit. Weigh the cobs and subtract from the weight of the ears, giving the weight of the corn. Divide the weight of the corn by the total weight of ears, which will give the per cent of corn. For each per cent short of standard a cut of one and one-half points shall be made.

4. In judging corn, a red cob in white corn or a white cob in yellow corn shall be cut at least two points. For one or two mixed kernels a cut of one-fourth point, for four or more mixed kernels, a cut of one-half point shall be made. Kernels missing from the ear shall be counted mixed. Difference in shade or color, as light or dark red, white or cream color, must be scored according to variety characteristics.

5. Exposed Tips—Where the full diameter of the cob is exposed, a cut of one point shall be made and a proportionate cut as the cob is less exposed. Regularity of the rows near the tip, and the size and the shape of the kernels, must also be considered in scoring tips.

6. Scoring Butts—If the kernels are uniform in size and extend over the butt in regular order, give full marking. Small and compressed or enlarged or open butts are objectionable, as are also those with flat, smooth, short kernels, and must be cut according to the judgment of the scorer.

7. Each exhibit should consist of ten ears of corn.

Saunders. I aim to save my seed corn in the fall. As soon as the corn is ripe and dry enough, I have my men go through the field and pick the ears that I have told should be gathered. After they are brought in, I select the best from these and then place the ears in a dry and cool place. They should never be put in the cellar. I believe that the best way is to tie them together with a string, as has been said, and then hang them up so that nothing can injure them.

A bushel of corn will plant about seven acres of ground. By good cultivation one should raise one thousand bushels, which would well represent five hundred dollars. From a money point of view it is worth while to see that we have good seed corn.

When we have inferior seed, a number will not sprout, or do any good if they do. I am satisfied that there are at least ten out of every one hundred stalks of corn that are barren. This makes three hundred and sixty stalks barren in an acre, if the corn is planted three feet and six inches apart each way. This makes us lose fifty dollars from a planting of one bushel of seed corn. I believe, as you do, that the selection of seed corn is one of the most important things in farming, and it should certainly be attended to with great care. We cannot be too careful about it. I wish I could impress this upon every one as you see it.

Drenan. I know a man who increased his yield per acre eighteen bushels by carefully selecting his seed corn. Suppose that only ten bushels increase to the acre could be shown. What a large addition this would be to the national wealth!

In Kentucky, according to Bulletin 163, issued by the State Experimental Station at Lexington, there were 3,436,340 acres in corn in 1910, and there were produced 83,348,024 bushels, which made an average of 24.3 bushels per acre. Suppose there were an increase of fifteen bushels per acre because of the proper selection of seed corn, there would have been raised 135,048,162 bushels, and at fifty cents per bushel there would have been added to the wealth of the State $25,850,169. This and more could easily be done by the proper selection of seed corn.

Prof. Holden, of Iowa, demonstrated the value of good

seed corn by increased yields. Gov. Cummings, of Iowa, says that the yield in Iowa has been increased 27,000,000 bushels a year through the efforts of Prof. Holden.

The proper selection and care of seed corn are indeed very important, and but little attention has been given to them. Besides, an increase in production is demanded. It is used in very many ways, and the demand is increasing. I wish I could write a letter to every farmer in the world and impress upon him the great importance of having good seed corn to plant. Some would pay attention to it and others would not. I believe that on the whole it would do much good. I feel like being useful and of some help to every one, and in this humble way, if I could tell how important it is, I know I would be doing some good anyway. I see that you feel the same way. I am glad to know this.

Saunders. While it is necessary to give much attention to selecting and taking care of seed corn, yet I believe proper cultivation of the ground also has much to do with producing a large crop of corn.

CHAPTER XIII

PLANTING AND CULTIVATION

Drenan. Assuming that the seed-bed is properly prepared, we then plant the corn. It should not be planted until the weather is warm and suitable—so many people get in a hurry. Early planting is all right if the weather is warm and the corn which comes up is not hurt by cold or cut down by frost. Of course it should not be planted so late that it would not mature.

Saunders. People differ as to the depth corn should be planted. How deep do you plant your corn?

Drenan. I have a sandy field over here that is planted deeper than the clay field you see in front of us.

Nature has stored enough food in the kernel for it to sprout and start to growing. It is better to plant deeper in sandy soil, so that the seed can get more moisture, and because of the looseness of the soil the plant can easily find its way to the air. It must have air and put out leaves, so it can live from the air and get food from the soil through its roots.

The field in front of us is a clay soil and is heavy, and in order for the corn to germinate and reach the surface it must not be planted deep. Do you drill your corn, or how do you plant it?

Saunders. I like to plant my corn so I can plow it both ways. I plant it three feet and six inches each way, and three grains in the hill and then thin to two. I have a drill that will plant three grains to the hill and cover well, and it has an attachment which fastens to a wire, and every time it strikes a cross-piece on the wire it drops the corn. You would be astonished to see how perfectly it is planted, and in such straight rows, too, at that. I consider the

machine an extra good one, and would advise you to get it. It is named Evans' Planter and is manufactured at Springfield, Ohio. I would advise you to send and get a catalogue of the machine anyway, and then send for one when you can. There are quite a number in the market, and a person cannot make a mistake if he gets one from a standard manufacturer.

Drenan. It is important to get the seed put into the ground properly, but I consider the cultivation and feeding of the plant from this time on to be of prime importance. What we have heretofore been talking about is very important—I consider that here is where the skilled farmer shows his skill and greatness. We plow corn for three reasons: First, to destroy the weeds; second, to conserve the soil moisture; and third, to aërate the soil. If we do not kill the weeds they will take the plant food from the soil, and also the moisture. As the weeds are hardier and more thrifty, they will outstrip the corn and smother it to death, so to speak. No filthy field ever raised the maximum amount of corn.

It is necessary to stir the ground a great deal to conserve the soil moisture. When the ground is not plowed you will see little cracks in the ground, and these let out the moisture. The loose soil is like a blanket on the ground. If you place a blanket on the ground and let it stay any time, the earth under it will be moist. There is evaporation going on all the time, and when it comes to the surface, if it is covered with loose dirt it will keep it like the blanket and compel it to go out through the roots of the plant. In this way the plant will get the proper nourishment. By repeated plowing we make a loose mulch on the surface, and the capillarity is broken up and the moisture is retained. The plant thrives the best when it has plenty of moisture; cut it off and it dies, or give it an insufficient amount and it suffers accordingly. By keeping the soil mulched we prevent the escape of the moisture, or at least we keep it to a minimum.

The different Experiment Stations, and especially the Wisconsin Station, say that there is not enough moisture in the soil in the United States, at any one place, to raise the greatest yield of corn. Then it is very necessary to

conserve as much of it as we can. The leaves on the corn have little mouths on them, called stomata, and through these the moisture goes out. When it is very hot these little mouths open as wide as possible and the moisture goes through them and the temperature of the corn is kept at the proper degree. They are like the pores in the skin of an animal; thy permit the heat to pass out, and the temperature of the body is thus kept down.

Saunders. I see from the reports given out by the Experiment Stations that moisture is conserved by frequent cultivation. I have seen large crops grow with shallow cultivation, and I have also seen large crops grow with deep cultivation. Ever since I saw the field of corn belonging to Mr. Bascom, in Bath County, raised by shallow cultivation, I have believed it to be the best. He raised about 125 bushels of corn to the acre. It was at that time about the best yield in this country. Since then it has been passed. At that time it was considered about the best in the whole country. He did not plow over three inches.

Drenan. The object of cultivation is to conserve the moisture and make it pass out through the roots and leaves. The Experiment Stations have been trying experiments for some time, and it has been fully shown that deep cultivation will conserve the moisture better than shallow. When shallow cultivation, however, is used, there is more corn raised to the acre than when it is plowed deep. The reason for this is that every time we plow deep we cut the roots, and as these cannot grow together, the plant has to exert some energy to cover the wound and to start some more rootlets. Deep cultivation will then destroy one of the essential parts of the plant life, and if continued it will impair the vitality and cause a less yield.

If you will take two rows of corn, and cultivate one deep and the other shallow, you will see the one which you have cultivated deep has the leaves turned up and looks sickly and produces less, while the other row will grow vigorously, and under proper conditions of moisture will raise the maximum. I would say by all means to practice shallow cultivation, and I would plow as frequently as I could, and especially soon after every rain. It is said that you need not plow only after every rain, but this plowing

should be done as soon after a rain as possible. It should be cultivated as soon after a rain as can be done with safety. It is absurd to say we should wait until another rain before it is plowed again. It should be plowed often. I do not believe we can plow too much. Always keep the soil mulched well. As soon as we plow a good-sized field we should turn around and plow the other way. We can't plow it too often.

Saunders. Do you plow with the shovel plows, disk, or tooth plows?

Drenan. I have a plow with a number of little shovel plows on it, and I use this. I do not believe it is the best, but it is the best I can find. I have invented a plow of my own. It combines the small plows and several flat blades which go through the ground about two inches deep. These blades are so fixed that they cover the whole row, and we are sure every weed is cut off. It has the effect of leveling the dirt. I may apply for a patent on it. I do not know whether it has been made before or not. It is a good one. If any one wants to make one I will send him a drawing and he can easily make it. Never plow over three or four inches deep. I think I have a picture of the plow I have made, and I will give you one so you can take it home with you. You want the soil plowed, and then you want to be sure and have the weeds cut and the ground leveled. It is not so much the leveling that does good, but it shows that the blades have gone through the soil and that any weeds left have been cut.

Saunders. I have not seen such a plow, and I wish you would make me one and send it to me, and I will pay you for your trouble. I am going to try and beat you raising corn another year. I have become very much enthused. My prediction is that you will raise over one hundred bushels of corn to the acre. Did you feed the plant anything while it was growing? You know that some people have practiced feeding the plant while growing and have produced wonderful results.

CHAPTER XIV.

FEEDING THE PLANT

Drenan. Yes, I feed the corn while it is growing, and I believe it right to do so. You know that manure adds nitrogen, phosphoric acid, and potash to the soil, and also other elements. It puts the soil in such condition that the insoluble parts of the soil are made soluble, so that roots can take it up. It is not only useful for the three elements I mentioned, but the chemical condition it puts the ground in. The air can better get through the ground, and the carbonic and nitric acids—and perhaps also sulphuric acid —take hold of the iron and alum, and release the lime, magnesia, nitrogen, phosphorus, and potash, so that the innumerable mouths of the rootlets can take these in and we thus secure the maximum crop. I believe that the ground should be well manured and plowed under and the ground thoroughly pulverized, and if we had manure enough to again spread some on it, it would be better, and then harrow it well in.

When the corn is growing, it is my opinion it should also have some food. Cottonseed meal is said to have more nitrogen in it than any other substance. It is well to make your own fertilizer. A good mixture is two hundred pounds of cottonseed meal with six hundred pounds of acid phosphate and two hundred pounds of muriate of potash. Put this on, three to five hundred pounds to the acre. Sow it broadcast, and then plow it well, but not deep. The roots of the corn have innumerable little mouths ready to grab it and take it through the cornstalk and blades and manufacture the ear. The better it is fed the better finished product you will have.

Two things are needed to raise the largest crop possi-

ble: First, available plant food during the period of growth; second, abundance of moisture. If one has practiced deep cultivation there will be plenty of moisture stored in the ground, and with the cultivation to make a soil mulch, one should raise a crop anyway, but of course it would not be as large as if it had plenty of rainfall.

It has been determined that when fifty bushels of shelled corn is taken off the land, together with the fodder, you take with it eighty pounds of nitrogen, twenty-nine pounds of phosphoric acid, and forty-five pounds of potash. If you repeat this year after year, you see in what condition you put the land. By looking at the amounts of the different elements we can see what should be added.

Saunders. You know that different lands require different treatment, and we must use judgment in determining what to put on. You certainly would not put as much nitrogen on a black soil as you would on a light, sandy soil. I expect we lose a great deal of money in not looking and using judgment. If we understood chemistry and knew the effect of different things on the soil we might get better results, and in fact I know we would.

Drenan. If you will walk with me through the bottom field, you will see that I have not used the same fertilizer on the different parts of it. On some parts I have put more potash and phosphoric acid, and on some other part I have added a larger quantity of nitrogen. It takes some experience to tell what should be done.

If you want to produce abundance of plant you must add the nitrogen, and if you want less plant but more roots, then add the potash.

Wheat requires very little potash, while root crops require a large lot of it. If we can afford it, it is best to have every element in the land.

Saunders. I have a large bluegrass farm, and I raise a number of acres of corn, wheat, and oats. Sometimes I like one crop better than another, and it is really hard for me to tell which I do like best.

Drenan. The corn crop is my favorite. I think it is one of the finest as well as the most important crop that grows. It reaches its growth during the hottest time of the

year, and just when chemical changes are taking place more completely. It is, in my opinion, the king of crops.

Corn is an ambitious forage. Sometimes the roots reach out in loose ground from ten to fifteen feet, and with vigor and strength into the remotest parts, and grab the iron and alum and other insoluble elements and lock them in embrace, and pour upon them an ointment which compels them to weaken and finally to dissolve, and then they seize the parts and take such as are needed for their own life. Under proper conditions the work is magnificently done. Sometimes I am led to believe that corn helps to renew worn-out soil. It seems to be able to get sufficient nitrogen. In my opinion, corn needs plenty of potash and phosphoric acid. It is well to add these in the form of fertilizer. I do not mean to say that we should not add nitrogen, but what I do say is that corn seems to be able to get nitrogen from some source, even if it is not added.

Saunders. I expect you are right. The uses for corn have increased, and it does look as if more and more will be raised in the future. Indeed a man is a benefactor of the human race who blazes the way for the farmer to increase very largely his output per acre. It can be done, and must and will be. Our forefathers have left a trail of desolation behind them. Extensive fields once raised magnificent crops, and to-day they are left desolate and alone. Nature is doing what she can, but she needs the assistance of that magic wand which you call Science. Somehow or other I believe the time is near when these worn-out lands will be restored to almost primitive fertility.

Drenan. You have been making me do a great deal of talking, and I see from what you say that you are no entered apprentice in the art of corn-raising yourself.

Saunders. While I have given the subject some study and attention, I am free to admit that I have not given it the close study you have. You spoke something this morning about ground limestone and ground phosphate rock. I am anxious to know more about these. I have heard the lecturers at the farmers' institute talk about lime and phosphates, and I have been anxious to give them some study and also a trial on some land. You certainly don't believe that ground limestone is as good as burnt lime?

CHAPTER XV

LIME

Drenan. Before going out to the field I will take some litmus paper with me, so we can test the soil and see whether it has too much acid or too much alkali, or is neutral. As I explained this morning, litmus paper is made of a vegetable substance, that will turn red when acid is put upon it and blue when an alkali is applied.

Saunders. Where do you get this paper?

Drenan. You can buy it from any druggist. Ten cents' worth will last several years. I put it in a bottle and cork it tightly, so as to keep it dry. Chemists use this paper constantly in experimenting. Indeed, they could not do without it. I believe that a knowledge of the qualities of litmus paper once saved my life. I was suffering with rheumatism, and had taken all kinds of medicine. Nothing seemed to do me any good. By the use of litmus paper, I found that there was too much acid in my blood. The paper became highly colored red when it came in contact with the secretions of the kidneys. I knew at once that I needed an alkali water to counteract and neutralize the acidity. I knew that the purest alkali water should come from the alkali lands of the Southwest. After trying several waters and studying their analyses, I found what was needed. I have been drinking water from Mineral Wells, Texas, for three years, and it has cured me. I am physically a new man, and believe I have a new lease on life. Send to the Gibson Well Water Company, Mineral Wells, Texas, and get a case. Before doing so, be sure and use the litmus paper. If the paper turns red when used, you should have the water. If it turns blue, you do not need it and should not have it. You would be adding

fuel to the flame. You need acid to counteract the alkali. Drink more lemonade and diminish the salts. You can help Nature. I cannot understand why doctors do not use litmus paper in the diagnosis of every disease. They could certainly arrive at more accurate results, and it would be scientific, to say the least.

Saunders. This litmus paper has wonderful properties, and I will try and remember what you have said. I am anxious to see how you use it with soil.

Drenan. Here, let us stop. Water has been standing upon this land for some time. You see I made a surface drain, and all the water has been carried off. I am now trying to put life into this land. I am now going to take up some soil and moisten it and roll it into a ball. I break the ball and put a piece of paper between the parts, and then place them back and let it stay from fifteen to forty-five minutes. I will let this one stay only five minutes. While we are waiting, let us go over to where I treated the soil with ground limestone. I am taking some soil from this and treating it as I did the other. I will now look at the paper. Here it is. You see it has turned slightly red, and I know therefore the soil has too much acid, and before it will raise clover, cow-peas, wheat, etc., this acidity must be corrected by an alkali. The soil should be neutral. The paper should turn neither red nor blue, and should be a mixture of the two colors.

Saunders. Let us now look at the other one.

Drenan. You see this is not neutral, but has turned a little blue. I put on it some burnt lime, and I put on a little too much. If I had applied ground limestone instead of burnt lime, it would have been better.

Saunders. This little piece of paper speaks volumes, doesn't it? What did you say was your reason for applying lime?

Drenan. Clover, alfalfa, and the leguminous plants are very sensitive to acid conditions, and the nitrogen-gathering and nitrifying bacteria will not thrive in such a soil, and hence you cannot raise these plants until this is corrected.

The chief reason for using lime is to neutralize soil acidity. When organic matter is decaying, it is accom-

panied by the formation of acids, such as carbonic, nitric, and humic acids, and unless there is enough lime in the soil to sweeten it, bacteria will not thrive and some plants will not grow.

Lime is used to correct, first, acidity in the soil; second, to correct the bad physical conditions, especially stiff clay; third, to serve as a base for the union of acids set free by bacteria in the soil, especially nitrifying germs; fourth, to aid in setting free plant food; and fifth, to aid in releasing phosphoric acid. Lime performs an important function. There is some lime in nearly all soils, but not in sufficient quantity to keep the land in sweet and proper condition. It is easily leached out. You would be surprised to know the condition of some of the newest soil. I have some land across the creek that I cleared this last year, and the soil is very black. I was surprised to learn that it was deficient in lime. You can go to the Bluegrass of Kentucky, where the soil was originally made from limestone, and you will find a great portion of land deficient in lime. I was out to St. Matthews, in this county, not long ago, and I found quite a lot of the land deficient in lime.

Look at that seven-acre lot near the road. It was acid, and I could grow scarcely anything on it. I bought a carload of ground lime and applied it. You see what a luxuriant growth of cow-peas I have on it now. I have never seen anything like it. When it is cut I am satisfied there will be at least four tons to the acre.

Lime is a disinfectant, and corrects conditions and makes pleasant habitations for the myriads of workers. It is necessary on rich soil because it neutralizes the acids which are necessarily made. Part of the corn field was clay, and the lime corrected it and made the soil loose and the ground was much benefited, as you can see from the corn crop.

The corn roots make an acid in the soil. This was discovered by planting corn in a big jar with a glass bottom. The corn was given the best conditions in which to grow, with plenty of moisture and food while growing. When the corn had matured it was removed from the jar, and the glass bottom showed etchings on it which nothing but acid could make. No doubt you have noticed rocks which had

some places on them which looked as if they had been chiseled out. These rocks were no doubt near the roots of some tree, and carbonic or nitric acid had been made by the roots and the acid had eaten these places. When vegetation grows, acid is formed by the roots, and if the acidity is not corrected and is permitted to continue, the nitrifying bacteria will disappear or do no work. Lime corrects it, and neutralizes the acid much as the water from Mineral Wells neutralizes the uric acid in the blood. The lime forms a base for the union of acids, and they become calcium carbonate or calcium nitrates, and make free food for plants.

If you have a sufficient quantity of lime in the soil it will not become sour, it doesn't matter how many crops of green manure you turn under. One should keep his land sweet and in proper condition, like he would his dairy barn for his own cows. He cannot get the best milk unless he treats them like Mr. Finley does. The army of working bacteria will do the best work when they have the best surroundings.

Saunders. I agree with you that lime should be put on land, and that any crop will do better when the soil has been treated with it. I heard at the last Farmers' Institute that I attended a discussion as to which is the better, burnt lime or ground limestone. It was advanced by some that burnt lime was dangerous, and that too much of it put upon the land would burn the nitrogen out and injure the soil. It was said by others that ground lime was the better, as the lime would be leached out as was needed, and that Nature would adjust everything. Others said that a small amount of burnt lime is better. From what I gathered from the discussion I am of the belief that ground limestone is the better.

Drenan. Certain parts of England are underlaid with chalk which is almost pure lime. In 1705, some farmers near Hertforshire dug down to the chalk and took considerable quantities out and put them upon the land, and these lands are moderately productive after a century of cultivation, while the lands which were not treated with the chalk have long since been unproductive. "Director Hall, of the Rothamsted Experiment Station, states that

many of the farmers of the vicinity are still reaping profitable crops from lands enriched by the heavy applications of chalk made by their ancestors many years ago." These applications were made of chalk as taken from the pit, and which was not burnt.

Lime rock when burnt is very caustic. When dampened and put upon your land, it will burn like an acid. When too much is put upon land in this condition, it will burn the life out of it. Nitrogen will be released, and it will go off in gases. By putting lime on manure you can readily make ammonia, and it soon disappears as gas, and nearly the whole value of your manure is gone.

If one has a very acid soil, and wants to neutralize it at once, then put burnt lime upon it. It should not be too heavy.

I believe it is best to put raw ground limestone upon land. A number of experiments have been made, and they prove to me that ground lime rock is the better. The Pennsylvania Station gives the following as the results of its experiments:

TWENTY YEARS' PRODUCE PER ACRE

Soil treatment.	Corn.	Stover.	Oats, Grain Bus.		Wheat, Grain Bus.	Straw, Tons.	Hay.
Burnt lime -------	699	16.5	617	17.8	318	14.6	23.6
Ground limestone	798	18.6	733	20.4	331	16.6	29.2

These show a greater increase when ground lime is put upon it than burnt lime. Indeed, the tendency of burnt lime is to exhaust or destroy the fertility. Director Patterson, of the Maryland Experiment Station, says: "It will be noted that carbonate of lime gave decidedly better results than caustic lime."

Neuffer of Germany, in his book, says that ground limestone should be used, and "not burned lime," for improvement of soils deficient in lime.

Porter and Grant, of the Agricultural Department of the County Council of Lancaster, England, report that ground limestone is more profitable on grass land than burnt lime.

Indeed, all the authorities I can find state that ground limestone should be used.

My firm belief is that the finer you have it ground the better. This exposes a greater surface and its activity is better. Suppose we take a cube two inches each way—depth, length, and thickness. There are four square inches to the side, and with six sides there are twenty-four square inches on the outside surface. Now let us cut this cube half in two each way; we now have eight cubes, one inch each way. There being six sides to each cube and one square inch to the side, we have six square inches in the outside surface of each cube, and with eight cubes we now have forty-eight square inches in the place of twenty-four in the first cube. So it is demonstrated mathematically that the greater division we have, the more surface we have. It would necessarily follow that the lime should then be ground as fine as it is possible to have it. If it were ground from eighty-five to two hundred mesh it would be all the better. There is greater surface exposed, and the ground rock has the better effect upon the soil. You can get good results from lime rock that is not ground so finely, but I believe the best results come from the finest mesh.

Here comes my foreman, Mr. Moremen, and I want you to know his opinion of the benefits of lime. Mr. Moremen, I want to make you acquainted with my friend, Mr. Saunders.

Saunders. Glad to know you, Mr. Moremen. I have been over the farm with Drenan, and it seems we have talked all about farming. We have just been discussing the propriety of putting lime on land, and I would like to know your opinion.

Moremen. When Judge commenced to insist upon liming his land, I thought he was going to spend some useless money. He was the owner, and got the rock, and had us put it on. I have been very much surprised at the results. I was raised in this neighborhood, and I think the land is hard to beat. For some reason or other the land next to the public road would not raise much. The water stood on it some and it was not well drained, but I did not see that it stood on it enough to hurt.

I saw Judge one day take a two-inch auger with him and some paper he called litmus paper, and go out to the field. He took the surface soil in different parts, moistened

it, and then put this paper in it, and let it stay about three hours. He bored down in different parts of the field from a foot to two feet, and he treated these borings the same way.

When the litmus paper was removed it was very red, and Judge said this showed the soil to be very acid, and that he would correct it with lime. We spread about two car loads of lime rock on the seven-acre tract. We then sowed it in alfalfa. For some reason or other we did not get a good stand. We let it grow up in weeds, and during the last week in July we turned them under and sowed the whole field in cow-peas, and you see what a great crop we have. Judge says he is going to turn them under as green manure and put in wheat. There is too much good feed on the field for us to lose, and I am going to insist upon his cutting it and putting it in the barn for feed.

Saunders. I see you are as enthusiastic over lime as Drenan.

Moremen. Yes, and I expect more so. My uncle owns about seventy acres of land four miles nearer Louisville than this farm. No crops in my recollection have ever been raised upon it. The water stood on it nearly all the time. It was certainly a sorry sight. My uncle keeps up with the times as much as does Judge. After he bought it he made a number of surface ditches and drained the land thoroughly; he then plowed it deep and spread burnt lime on it, and then sowed it in timothy. I wish you could have seen the timothy hay he raised upon it. He sold $600 worth from it, and you know this year was a very bad year to cure hay. You see why I have become enthusiastic over putting lime on land. Look what it did for our corn crops. I know Judge has explained that to you. He says he reserves that to tell folks himself.

Saunders. Suppose I should want some ground limestone? I would not know where to secure it or what kind I should have. I should think there would be different qualities, and that some would be better than others.

Drenan. That is so. There is more carbonate of lime in some rock than in others, and some are softer and more readily dissolved. You can find a limestone that is very hard and can scarcely be broken, and is almost impervious

to pure hydrochloric acid or any other acid. You would not want to spread that on your land. While some of the lime would dissolve, it would not have the effect you desire.

There is a great amount of oölitic limestone found in Western Kentucky. This rock is almost pure lime. In some places it is 99.4 per cent pure carbonate of lime. It is almost impossible to find it purer, and this is certainly pure enough for any purpose. This oölite is not found every place, and a large quarry of it is very valuable. It is made up of granular limestone, each grain being more or less spherical and made up of concentric coats of carbonate of lime formed around a minute nucleus, usually a grain of sand. It is called oölite because of its resemblance to the roe of a fish. Some people call it the fish-egg rock.

Saunders. The trouble with us farmers is that we do not know the kind of rock to buy and where to buy it. Freight rates play also an important part, and we have to look after these. It looks to me like the Department of Agriculture ought to keep us well informed, or at least should be able to do so upon inquiry. For some reason or other they seem to be afraid to tell us the names of manufacturers and how to get the product. They seem to be afraid to speak out, or they may think it is not prudent. By the time we find the kind to buy and where to buy it, it has become inconvenient or impossible to spread it. Now, where would you buy the limestone of which you were just speaking? I am sure I would not know where to buy it.

Drenan. The Webster Limestone Company, at Irvington, Kentucky, has this kind of rock. This company has a large crushing and grinding plant, and a large limekiln for burning the rock. Irvington is forty-nine miles from Louisville on the Louisville, Henderson & St. Louis Railway, and is a fine country town. The company has a vein of this rock twenty-eight feet deep, and near the surface. It is very fine rock for agricultural purposes, and in my opinion it is the best in the whole country. If you would write to Mr. G. A. Park, head of the Development Department of the L. & N. R. R. Co., he might tell you of other companies closer to you.

Saunders. Let me take down the names. I want to order some as soon as I return home.

Moremen. We know what lime has done where it has been put, and Judge is also a great believer in ground phosphate rock. I suppose he has told you about that?

Saunders. He has said much about phosphoric acid and some little about phosphate rock, and I would like to know more about it. In my opinion, phosphorus is about the most important element to be looked after. I would like to hear Drenan's opinion.

CHAPTER XVI

PHOSPHORUS

Drenan. In the average composition of the earth's crust, according to Prof. Clark, of the United States Geological Survey, there is sufficient iron to meet the needs of one hundred bushels of corn every year for 240,000 years, sufficient calcium for 61,000 years, magnesium for 7,600 years, sulphur for 21,000 years, potassium for 2,400 years, and phosphorus for only 120 years. It is said there is enough nitrogen in the air resting on an acre of land sufficient for the needs of one hundred bushels of corn every year for 700,000 years, and that there is only enough nitrogen in plowed soil for about fifty years.

We see from this that only the two elements phosphorus and nitrogen are likely to be soon exhausted. Both elements are very essential, and it is impossible to raise a good crop without them. We can secure the nitrogen from the air by putting in leguminous plants and by turning under green crops such as clover. We can also secure phosphorus by turning under green crops and manures.

It is assumed as a fact that an ordinary soil seven inches deep contains 1,200 pounds of phosphorus to the acre.

Let us suppose that we have four rotations of crops—two of corn, one of oats, and one of clover.

The two crops of corn will take forty-six pounds of phosphorus, the oats sixteen, and the clover twenty, or a total of eighty-two pounds. It would then take only sixty years to exhaust the soil of the phosphorus.

In countries like India, where farming is very unscientific, the phosphorus has nearly all been removed, and

there is left only a trace. The soil, under the very best conditions as to moisture, raises only a minimum crop.

The farmer who sells his corn, wheat, and oats sells a large part of the fertility of the soil. The grain contains two-thirds of the nitrogen, three-fourths of the phosphorus, and only one-fourth of the potassium; while only one-third of the nitrogen, one-fourth of the phosphorus, and three-fourths of the potassium are in the stalk or straw.

The farmer usually keeps the stalk and straw on the farm and sells the grain. He then adds to the soil a greater proportion of potassium, when this is not really needed. By selling the grain, he takes away the larger portion of two very important elements, and if continued it necessarily leads in course of time to soil depletion.

You can obtain nitrogen from the atmosphere and from the soil, and by turning under several green crops of leguminous plants you can restore all necessary nitrogen. In doing this you should sweeten the land with ground limestone, and thus prevent it becoming sour. It is well to remember that land will stand any amount of green manure, or any manure, provided there is enough lime in it. The nitrogen can be brought to a high degree in amount in the soil by manures.

Saunders. From the figures you give, and from the fact that you cannot get phosphorus from the air, and further that it must be gotten from the soil at first, you leave me under the impression that it is the most difficult element to obtain, and also that it is one of the most important. It seems to be so limited in quantity, and with a possibility of its exhaustion within sixty years, even in crop rotation, that the question of adequate phosphorus retention and supply is a very weighty one for the farmer, and indeed a very grave one for every citizen of the whole world.

Drenan. I see you have anticipated me again. It is a very grave matter for the whole world. People must be fed, and the more that can be raised on the land the easier it will be. On some of the fertile bottoms in India, where the lands are irrigated and where there is only a trace of phosphorus, the maximum yield of wheat is twelve bushels.

In this country, Nature has made extensive phosphate

fields in Tennessee, Florida, and South Carolina. When these rocks have been taken out and treated with acid, or finely ground in the rough, and then put upon the lands deficient in phosphorus, there has been a large increase in the crops.

The manufacturer takes these rocks, grinds them, and then releases the iron and alumina by a treatment with sulphuric acid, and puts them in a filler and sells the product as a complete fertilizer. On certain lands the crop is increased by the addition of this phosphorus.

Some people contend that when a high-grade phosphate rock is ground finely and put on the land which contains organic matter, it will put more phosphoric acid into the soil in the long run, and will be better and more economical.

In order to produce the maximum crop there must be sufficient phosphoric acid in the soil, and there should be a sufficiency to last several years. You can restore the phosphorus by manures made from food containing it, but this is robbing one soil to aid another.

The different Experiment Stations have been trying to solve the problem as to which is the better, soluble phosphoric acid or insoluble phosphoric acid. The soluble is the manufactured product treated with acid, and the insoluble is the ground phosphate rock.

Phosphoric acid in a soluble form sells in the market for from four to six cents per pound, while the ground insoluble phosphate rock sells for two cents. If good results can be gotten from the insoluble, it is certainly cheaper.

A ton of ground phosphate rock contains from 200 to 300 pounds of phosphorus, and a ton of acidulated phosphate contains 122 pounds. The latter is made soluble by the acid treatment and is available at once for plant life, and the former must be put into soil that has a large quantity of decaying matter, and it will soon reach a chemical condition suitable for plant life. The high-grade phosphate rock will cost $9 and you will have 300 pounds of phosphorus in the soil, while the high-grade fertilizer will cost $18 and you will have only 122 pounds of phosphorus in it. Is the acidulated rock worth the difference?

The Ohio Experiment Station has well established that a

ton of ground phosphate rock, mixed with a liberal amount of decaying organic matter, will give practically the same profit per acre as a ton of acid phosphate, and it will give twice as much profit on the money invested. Certainly 300 pounds is better than 122 pounds.

Here is a table of the Maryland experiments with different forms of phosphorus:

TWELVE YEARS' WORK; YIELD PER ACRE OF THREE PLOTS

Plots	Phosphorus Applied	Six Corn Crops Average		Two Wheat Crops Average		Three Hay Crops Av. Tons	Total Av. Yield Tons
		Grain Bus.	Stover Tons	Grain Bus.	Stover Tons		
8, 13, 18	Raw Bone Meal	39.6	1.25	23.6	1.22	1.85	6.41
9, 14, 19	Slag Phosphate	39.1	1.22	22.6	1.24	1.95	6.46
10, 15, 20	No Phosphorus	40.0	1.17	12.1	.73	1.44	5.10
11, 16, 21	S. C. Rock Phosphate	39.7	1.25	20.1	1.07	1.95	6.26
12, 17, 22	Florida Soft Rock	42.5	1.27	19.9	.94	1.89	6.19

We see from the above that the application of phosphate rock produced good results.

The Pennsylvania Experiment Station reports that raw phosphate produces larger results than the acid phosphate.

The reports from all the Experiment Stations, as far as I have been able to find, show that the application of ground phosphate rock increases the yield. You can spread two tons of rock for the same cost as one ton of acid treated.

Director Jordan of Maine, in his 1894 report, in speaking of the increased yield because of the application of raw phosphate rock, says: "This is certainly one instance of the unmistakable persistent influence of a crude phosphate in increasing the growth of a field crop."

The supply of phosphate rock is limited. It is found in very few places in the United States, and unless other fields are found these will be exhausted before a century passes.

There were exported from the United States in 1908, 1,188,411 tons of phosphate. Our phosphate fields are being drained for the benefit of worn-out farm lands of foreign countries. We need all the phosphate we can pos-

sibly produce in this country to help restore the havoc, devastation, and utter ruin produced by the savage onslaught on the fertility of the soil by our ancestors. Our statesmen should wake up and realize they owe a duty to coming generations. A high enough tariff should be put on the exportation of raw phosphate rock and phosphate fertilizers to keep them at home.

We need these rocks to help restore the old thrown-out farms in Virginia, Georgia, Alabama, the Carolinas, New York, Connecticut, and in fact in every State in our Union. We should have every pound that is produced, to help restore these wildernesses of desolation and to help increase the fertility of the acres which are not destroyed.

I wish that I could sound a bugle-blast that would be heard all over this land of ours. I would certainly warn all to prevent great future disaster and to do the best that can be done to restore original fertility.

England draws phosphate from the four corners of the world. Her imports in 1885 exceeded 250,000 tons, and they have been increasing ever since. In 1892, the United States furnished her with over 200,000 tons, and in addition she has some phosphate deposits in the form of phosphatic nodules in the eastern and southern counties. England has increased the fertility of her soil, and has drawn upon the whole world to do so. Complaint has been made that in her eagerness for bones to enrich her soil she has dug up and stripped the battlefields of Leipzig, Waterloo, and the Crimea, and carried away the skeletons of successive generations from the catacombs of Sicily. By adding manures, phosphates, and lime, she has enriched her soil and increased her production.

In 1890, France used 400,000 tons of phosphate, and in 1899, 600,000 tons. Germany applied 800,000 tons during this last year, and in 1911 she used over 2,500,000 tons.

All the countries of Europe have largely increased the fertility of the soil by the application of phosphates, and this has been the chief cause for the increase in the size of their crops.

In Germany, the yield of wheat has risen from 12.1 bushels per acre in the Sixteenth Century to 35 bushels in the Twentieth Century, rye from 13 bushels to 30, barley

from 14 bushels to 40, and oats from 14 bushels to 45. There has been equally as large increases in France.

Both of these countries support a crowded population, and while the population has increased, the productiveness of the soil has also increased.

Saunders. It is different in the United States. Our population has increased, but the fertility of our soil has decreased. There must surely be something wrong.

Drenan. The United States stands in the front rank for the rapidity of soil exhaustion. A number of things have combined to bring this about, namely, the rapid development of great transportation lines has enabled the farmer to find a ready market for all he raises; the invention of agricultural implements, enabling one man to do the work of many, and which enables him to remove much from many acres of soil without returning anything; the improvement of seed, which enables him to produce more; and the scarcity of farm labor, the country being deserted and the cities overcrowded.

Our farmers were miners. The coal-miner takes the coal away, and when the mine runs out he seeks another. Our fathers have mined the fertility of the soil, and when they had exhausted it they too hunted other lands. Consequently we have agricultural ruin over vast areas of the older parts of our country, and rapid decreases in rich soils of the younger States, as Indiana, Illinois, and Iowa.

In the abundance of our harvests we should not forget the famines in Russia, the hunger in India, and the starvation in China, all within the last five years. May not this come to us, and sooner than we expect? We find extreme poverty among any people who are dependent upon agricultural resources of ordinary land, where the same has been cultivated for two hundred years.

Soils that have run down can not be restored economically within a year. It takes time and capital. We are now a rich and prosperous nation, and if we ever expect to restore and improve our soils we must do so while we are such.

Our vast wealth of phosphate deposits must be utilized, and not suffered to go hence. A weighty problem rests upon our Government, and I believe it will be equal to the

emergency. The protection and renewal of soil fertility are paramount issues, and the American people are going to solve them successfully.

Saunders. You are very earnest and enthusiastic. As phosphorus in the soil is very limited, and cannot be taken from the air and must be from the soil, it looks reasonable that we should restore it with the ground phosphate rock, and especially when it can be gotten so cheaply. I want some, and would like to know from whom I could order, so as to get a pure article.

Drenan. You can order it from the phosphate companies at Mt. Pleasant, Tennessee, and no doubt the postmaster there could give you their names. You can also buy it from Wood, Stubbs & Company, Louisville, Kentucky, Southern Seed Company, Louisville, Kentucky, the Hall Seed Co., Louisville, Kentucky, or any good seed company. Be sure and get the high-grade phosphate rock, even though you have to pay more.

Saunders. It is nearing the close of the evening and I must reach Louisville in time to take the C. & O. train for Lexington to-night, and as you have promised to take me in your automobile, I expect we had better be going.

Drenan. I would like for you to stay longer, but as you say you are compelled to go, I will bring around the machine and by that time Mrs. Drenan will be ready and we will soon be in the city.

CHAPTER XVII

THE GERM THEORY AND THE STATE FAIR

Saunders. I have spent a most delightful day, Mrs. Drenan. I enjoyed your dinner, and I was more than pleased to learn something about your success at canning. Mr. Drenan and I have talked farming, politics, and religion. He says he intended to go to his office to work to-day, and as he did not go, and devoted the day to me, I feel very much complimented. He insists upon my staying all night. I cannot do this, and will be compelled to take the C. & O. train for Lexington so I can reach home over the L. & N. early in the morning.

Mrs. Drenan. I know Mr. Drenan has enjoyed your visit, and I expect to hear him speak frequently and pleasantly of you. Such visits are like sunshine—they bring much joy and happiness.

Drenan. As you are compelled to reach the train by six o'clock we will hurry along, and you will be surprised how quickly we will reach the depot.

Saunders. You certainly have a good farm, but a person has to know how to manage the land before he can get the best results. Drenan certainly knows how. He has treated the south side of the field here with lime, the north side with manure and phosphate, and the field just beyond with a prepared fertilizer with potash predominating. The magnificent crops show his good judgment. Any man who knows how to do this is capable of managing thousands of acres, and it would certainly be a good investment for a man with large capital to go into partnership with him. I believe he could make large sums of money for himself and a partner. What do you say about it, Drenan?

Drenan. You know how to make any one feel good, and I appreciate your high opinion. I farm because I love the science. It is fascinating. A number of my friends go every Saturday afternoon to the Country Club and to the Audubon Club and play golf. This is good recreation for them, and as they enjoy it, it is right for them to go. I spend my Saturday afternoons on the farm, playing farmer. It may not be any more profitable than the golf game, but I assure you I enjoy it much more than I would golf. I believe that in my recreation I can do good for myself and others. I try to make two blades of grass grow where only one grew before. This has become a passion with me. I love the opening bud in spring, I rejoice with the waving wheat and rye, and I adore the golden grain.

I have seen the abandoned and worn-out lands in the black belt of Alabama, and an almost irresistible impulse came over me to go and caress and even sympathize with them in their loneliness and to feed them back to life. In my imagination I could see them once more spirited, running a rapid speed, like a high-strung thoroughbred. I have always felt the same tenderness and affection for the lands I owned as I did for the old family horse that carried safely my wife and babies. It is no more a shame to let the milch cow go hungry than it is to starve and impoverish the land that sustains you.

Mrs. Drenan. Do you see that fine building on the high hill to your right? That is the Tuberculosis Hospital. The consumptives of Louisville are brought here and treated scientifically. They live and sleep in the open air, summer and winter. You have no idea how many patients have been cured. I hear the doctors are making some wonderful cures.

Saunders. We may abuse doctors, but the very moment we become sick we certainly want one, and the public laws should so safeguard us that only competent physicians should be permitted to practice.

Drenan. A conscientious, high-minded, and thoroughly trained physician is an important factor in our modern civilization. Physicians are self-sacrificing and anxious to benefit humanity.

Dr. Carroll Reid discovered that the yellow-fever germ

was carried by the mosquito and gave his life to demonstrate the fact, and now yellow-fever epidemics in Havana are matters of history.

Dr. Thomas B. McClintock discovered that the Rocky Mountain spotted fever was caused by the woodtick, and he too gave his life as a ransom. Since then this dreadful scourge in the great West has been wiped out.

The Panama Canal was made a possibility through the efforts of Dr. William G. Goggess. He turned the most unhealthy region in the world—a valley of sickness and death—into one of the healthiest, and made it easy for Col. Goethals to dig and construct this gigantic piece of engineering. We should certainly erect a monument in the most commanding place to perpetuate the doctor's memory and to show our gratitude for his devotion and valor.

Saunders. The medical profession has certainly made great discoveries within the last twenty-five years. A child of one of my neighbors was saved from a dreadful death by injecting a serum for membranous croup. A few years ago the child could not have been cured. Diphtheria is no longer dreaded. I see that typhoid fever is being controlled among the soldiers in the United States army. This is certainly a wonderful age. I read in my home paper not long ago that the great advancement of medical science was due to the discovery of the germ theory. I heard Drenan say one day that he had a case in court where he had to become thoroughly posted on the germ theory. You know, Mrs. Drenan, lawyers have to post themselves fully on a subject which is being tried in court, so as to examine witnesses in a competent manner. I have often wondered how they knew so much, as they cross-examined oftentimes doctors, and learned doctors too at that, in such a way as to indicate they knew more than the doctors.

Drenan. You are nice in saying something pleasant about lawyers. They are usually looked upon as necessary evils. I believe that a conscientious lawyer is a very high type of citizen.

I have given bacteriology some study, but not enough to say that I know anything about it. I do not see why doctors did not discover the bacteria theory before they did. The profession has always been composed of learned

men. It was left for the latter part of the last century to make this great discovery.

The first complete study of contagious affection was made by Pasteur in 1869, which he showed to be due to microörganisms. Koch, in 1875, discovered the anthrax bacillus, and described its spores and the properties of same, and he cultivated the germ in artificial media. Pasteur and his pupils then followed this up by inoculating the germ from pure cultures in animals.

From this time on, bacteriology has assumed large proportions and has become a great science. The whole world has been benefited, and will continue to be by the earnest work of thousands of men in the study of diseases.

Bacteria are cells, and can only be seen through a powerful microscope. These bacteria may be of any shape; some are round and some are cylindrical. Each disease seems to have different-shaped bacteria. They multiply by division, so that one bacteria is soon capable of multiplying into millions. The cultures are grown, then colored, and then they can be seen through the microscope. Dr. Koch describes the tuberculosis bacilli as being very slender, about one-quarter of the size of the red corpuscle's diameter, with ends rounded, usually solitary but oftentimes lying in pairs in such a manner to form an acute angle, and they do not possess self-movement. A doctor experienced in bacteriology can then very easily diagnose tuberculosis. Typhoid fever has a peculiar germ with little arms, or flagella, on the sides. When they are once seen you never forget them.

Saunders. Then diseases are nothing more or less than the result of one life living upon another? It looks like it is absolutely necessary for successful physicians to thoroughly understand bacteriology to diagnose diseases and to treat them.

Drenan. Yes, and I believe that the medical profession in the future will not graduate a doctor from the schools unless he has become skilled in this branch.

Since diseases are contracted by coming into contact with the particular bacilli, we should all have some knowledge of this great science. The common drinking cup has gone, and the common towel is soon to follow. Many dis-

eases can be prevented by having a knowledge of this science, and in my humble opinion this subject should be taught in our public schools. Cut out so much Latin and Greek, or some other things, and have the children study more chemistry, physiology and hygiene, and bacteriology. There is something radically wrong in the course of study in our public schools. I saw a woman get on the street car the other day, and she took a nickel from her pocketbook, put the nickel in her mouth, then closed her pocketbook, and put it back into her hand-bag. She did not know with what disease the nickel had come in contact, and she did a very wrong act. Now if that woman had knowledge of the germ theory, I am sure she would not have acted so. It is said that diseases of the teeth can be communicated by kissing, as well as other diseases, and yet kissing is very fashionable indeed. I know of a dreadful disease being communicated to another by smoking the same pipe another had smoked.

Mrs. Drenan. I know if you get Mr. Drenan started talking about schools he will talk you to death on that subject. Some five years ago, I heard him say that the drinking cup as used was a menace to health, and that it would soon be prohibited. He is a great believer in manual training schools, and if I am not mistaken he predicts that this will be added to the curriculum of every school.

Drenan. Yes, I believe every girl should be taught how to cook and make dresses, and should be taught domestic science in full. The boy who is going to be a farmer should be taught the practical and theoretical side of it. When he graduates or quits school he should be an expert in cattle judging, know all about horses, as well as having a thorough knowledge of cultivation.

Mrs. Drenan. I knew we would get him started. Mr. Saunders, over to your left is the State Fair grounds. I am sorry that the people of the State do not take a deeper interest in the Fair. I took my canned goods to the Fair this year. I felt it to be a duty. I believe every individual citizen should do what he or she can do to make this Fair a big success. Mr. Newman, the Commissioner of Agriculture, is an able man, and one who desires to do his duty to the State. Don't you think you should bring some exhibits

down to the Fair next year? If there was a State-wide interest in the Fair, it would be a grand success. We must all help Mr. Newman. I intend to do what I can, anyway.

Drenan. I see that some one else can talk on a subject in which she is interested. I can agree with you in every word you have said.

Here is Louisville. It has not taken us long to come. Louisville is destined to be one of the great cities of the country. It is certainly growing very rapidly. We have in this city as high a type of citizenship as any you can find. Its geographical position, linked as it is to the world by a number of trunk line railroads and a large navigable river, give it a commanding position which will aid it in becoming one of the large cities of this continent.

Here we are at the depot, and in plenty of time for your train. I am sorry to see you leave, and wish you could spend more time with us.

Saunders. I have enjoyed the day very much, and in saying good-bye to you, Mrs. Drenan, I want to express my appreciation for your nice dinner and your instructive talk about canning and the State Fair. I am going to try and show something at the Fair next year, and I hope I will be able to do as well as you have done this year.

I want you, Drenan, to write me and tell what your corn yields per acre, and also to explain the excreta theory as maintained by some of the officials of the Department of Agriculture at Washington, and how rotation of crops will maintain soil fertility. Come and see us, both of you, and as the train is about to leave, I will again say good-bye.

CHAPTER XVIII

CORN RAISED PER ACRE—MR. WHITNEY'S THEORY OF SOIL FERTILITY

LOUISVILLE, KY., NOVEMBER 15, 1912.

MR. FRANK SAUNDERS,

Poplar Plains, Ky.

MY DEAR DOC:

When you returned from Louisville you asked me to let you know how many bushels of corn I raised to the acre on the eight-acre field. It has just been gathered, and it has averaged a little over 100 bushels to the acre. I am a little disappointed, as I expected to gather at least 125. Considering that the field was thought by my neighbors to be worn out and almost worthless, I ought to be satisfied with 100 bushels, but to be candid I am not, and I intend to raise 150 bushels to the acre on this same field next year. It can and must be done.

You also asked me to explain to you the theory of some of the Government officials at Washington in regard to soil fertility.

Mr. Milton Whitney is Chief of the Bureau of Soils in the United States Department of Agriculture at Washington, and in Farmers' Bulletin No. 257 he has given his views in regard to soil fertility. The Bulletin is a very interesting one, and you can secure a copy by writing to the Department and asking for it.

The views advanced by Mr. Whitney are revolutionary, and are contrary to all the theories heretofore held by scientific men. This does not make any difference, as the truisms of yesterday are questioned to-day and proven false to-morrow. Bacteriology changed all the theories of dis-

ease. If Mr. Whitney's theories are based upon scientific facts, and are correct deductions, we must accept them.

It has been an accepted theory that soil is the product of completely decomposed rock. Mr. Whitney says this is a mistake, and that soil "is an unconsolidated rock containing the minerals which were present in the solid rock from which it was derived." Otherwise the original rock had disintegrated and had only slightly decomposed, and that this could be seen by the use of powerful microscopes; that these minerals exist in clay and all soils, and that they are slightly soluble; that a glass tumbler ground into impalpable powder and put into solution of volume of water equal the size of the tumbler, there should be in solution soluble matter of at least three per cent. He says: "It is largely a matter of the amount of surface for the water to act upon."

On page 10, he says:

"In all soils there are rock particles or minerals containing phosphoric acid and potash, and in all the soil solutions that we have ever examined—and we have examined hundreds of them from all parts of the country—you will be astonished to learn that the composition and concentration of the soil moisture, which is the nutrient solution spread throughout the surface soil of the earth for plants to grow in and to gather their food from—you will be astonished to learn that the concentration of this soil moisture is sensibly the same whether we examine your sandy truck soils on your river necks, your sandy clay wheat soils on the uplands, the Hagerstown clay in the valley of the Shenandoah, or the black prairie soils of the West. These minerals are contributing to the solution in which the plant feeds. As I have said, these minerals are difficultly soluble, but they are appreciably soluble. They are soluble enough to maintain a solution which is amply sufficient for the plants to gather their food from."

The surprising part of the Bulletin is on page 11, where he says:

"We have taken out of the soil its own moisture and have actually found similar quantities of phosphates, of

potash, of nitrates, and of lime, in the sandy soils of our truck region, in the 'worn-out' soils of Virginia, in the fertile limestone soils of Pennsylvania, and in the black prairie soils of the West."

He also says that it is impossible to tell how little a plant will use of phosphoric acid or potash when all other conditions are perfectly maintained. He instances the case of the seaweed which contains iodine. The most delicate methods fail to detect a trace of iodine in seawater, yet the seaweed is able to absorb it.

The author maintains that "the fertility of the soil is dependent upon four principal facts, viz., plants must breathe; plants must drink; plants must feed; plants must have a proper sanitary environment."

He maintains that oxygen must be applied to the roots for their healthy growth, and that stirring the soil not only introduces air into the soil but permits the noxious gases to escape which may be given off by the plants themselves "or produced by bacterial action on the remains or excreta of plants."

He maintains that plants must drink, and that water does not seek the plant, as we have always believed, but that the plant seeks the water—that moist soil holds its moisture and gives up only a small amount. He says that if we will take some soil having the maximum amount of moisture and put it into a tumbler, and then place some dry soil over it, and then cover the tumbler to prevent evaporation, we can see there is no appreciable interchange of moisture. He says that only the tips of the roots absorb water and mineral matter, and then only for a short time, and as they grow they soon cover with "balloon-cells" full of air, and this prevents further entrance of water or other material, thus protecting itself against its own effluvia; that the soil absorbs the excreta of the plant, and there is then healthy growth.

I have heretofore written what Mr. Whitney thinks of the composition of soil. He also maintains that whenever "the plant takes into its substance some of the mineral matter from the solution, the solid minerals in contact with the solution immediately dissolve, and the solution is re-

stored to its former concentration." He maintains that there is no such thing as soil exhaustion, and that it is "a relative phrase, and resolves itself into the question of the rate at which the solution can recover itself."

He maintains that plants must have sanitary environments; that plants, like animals, throw off excreta which must be disposed of. He maintains that bacteria kill themselves when permitted to grow too long; that the reason lime is good for land is that it takes care of the nitric acid which is formed by the nitrifying bacteria which acid would surely kill if permitted to stay. He says:

"We must put something on the soil to destroy or change their effluvia so that the bacteria can themselves go on working. We must clean out the soils as we do the stalls in our stables. If we do not, the substances given off by the plants, or the substances that are formed from those substances by the action of bacteria, will produce acid substances—will produce what we call toxic or poisonous matters, that will themselves seriously affect if not kill the crop."

He maintains that there is a "toxic material—a poisonous material—in the soil," and that no amount of fertilizers will correct it. This condition of soil must be changed, and the toxic substances thrown off by plants must be corrected or changed and we hasten this by cultivation, aëration, and by oxidation. He maintains that the fertility of the soil can be maintained "by arranging a system of rotation, and growing each year a crop that is not injured by the excreta of the preceding crop; then when the time comes around for the first crop to be planted again, the soil has had ample time to dispose of the sewage resulting from the growth of the plant two or three years before."

He also maintains that litmus paper will materially aid in telling what is needed, but that it is not an infallible test. That it is best to have some boxes and treat one box with lime, one box with ground phosphate rock, etc., and by actual tests see what is needed. I believe myself that this is really the best, but I know that litmus paper will tell whether acidity should be corrected, and for this reason we should use it.

Mr. Whitney maintains that humus is organic matter in a most stable form—he classes it next to coal. He contends that organic matter can be converted into humus by aëration and cultivation, and that the very moment it becomes humus it is so stable that it becomes innocuous to the plant. He further says that as soon as humus is formed it becomes harmless to the plant, and is not poisonous, but that organic matter in any other form may be harmful.

He says:

"The humus, apart from the physical effect it has in loosening up the soil and the absorbing effect it has in holding water, which may greatly increase the yield of crops, appears to be the form of sewage disposal for the crops. Through the aid of bacteria or by direct oxidation the excreta thrown off by the plant are just as effectually disposed of, so far as any toxic effect they may have on the plant is concerned, as if they had been thrown into the bay, and a soil that will produce humus is a fertile soil, because it is a well-drained soil so far as sanitation is concerned."

The theories of Mr. Whitney have not been accepted by all scientific men, and they are questioned by such men as Prof. C. Hopkins, of Illinois, and by a number of the State Experiment Stations.

When it is conclusively proven that Mr. Whitney is right, and that soil exhaustion can be corrected by crop rotation, all we will have to do is to send samples of soil to the Agricultural Department at Washington and a chemical analysis will show what crop to plant to purify the soil of the poisonous material left by the previous crop. When the Department can do this we can accept the theories advanced by the Bureau of Soils, but to be candid I must say they are too theoretical for me at the present time.

This letter is already too long, and you can have a full discussion of the subject by sending for Bulletins Nos. 257 and 245, and you can also secure Circular 4 from the Department of Agriculture at Washington, which will give you a complete list of all the circulars and bulletins issued by the United States Government, and you can obtain much useful information from them.

I am looking forward with a great deal of pleasure to your next visit, as I am anxious for you to see some hogs I have bought and to know how you have made such a success in raising them.

With best wishes for yourself and your family, I am

Yours truly,

Wm. J. Drenan.

CHAPTER XIX

EDUCATION—POSTSCRIPT TO LETTER

PS. As you are much interested in educational matters, I know you will do what you can to add physiology and hygiene, chemistry, and other sciences to the course of study in your schools. The Flemingsburg Graded High School is very progressive and up to date, and I expect to see Manual Training added for the boys and Domestic Science for the girls. The girl who graduates should be a skilled housekeeper, cook, and dressmaker, as well as thoroughly drilled in English, mathematics, and geography. The boys should be able to design barns and build if necessary. They should be good judges of stock, know how to raise and mature them—in short, they should be fully equipped to fight the hard battles of life as soon as they step into the arena. This is especially necessary in agricultural districts.

I may be wrong, but I feel that Butler in his Hudibras said about the right thing when he wrote:

> "Full many a lad returns from school
> A Latin, Greek and Hebrew fool,
> In arts and knowledge still a block,
> Though deeply skilled in hic, hæc, hoc."

CHAPTER XX

CONCLUSION.

This book is written in the hope that some thoughts have been planted which may hereafter become finished products, and in the spirit of being useful to my fellowman. They are better expressed in the beautiful poem by Sam Walter Foss in

THE HOUSE BY THE SIDE OF THE ROAD

Let me live in a house by the side of the road
Where the race of men go by—
The men who are good and the men who are bad,
As good and as bad as I;
I would not sit in the scorner's seat
Nor hurl the cynic's ban;
Let me live in a house by the side of the road
And be a friend to man.

I see from my house by the side of the road,
By the side of the highway of life,
The men who press with the ardor of hope,
The men who are faint with strife,
And I turn not away from their smiles or their tears,
Both parts of the Infinite Plan;
Let me live in my house by the side of the road
And be a friend to man.

I know there are brook-gladdened meadows ahead
And mountains of wearisome height,
That the road passes on through the long afternoon
And stretches away to the night;
But still I rejoice when the travelers rejoice
And weep with the strangers that moan;
Nor live in my house by the side of the road
Like a man who dwells alone.

Let me live in my house by the side of the road
Where the race of men go by;
They are good, they are bad, they are weak, they are strong,
Wise, foolish—so am I;
Then why should I sit in the scorner's seat
Or hurl the cynic's ban?
Let me live in my house by the side of the road
And be a friend to man.

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